A Summary of Current Program and
Preliminary Report of Progress

OILSEEDS AND PEANUT RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs. The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
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TABLE OF CONTENTS

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil and Water Conservation
2 - Utilization--Eastern
2 - Utilization--Northern
2 - Utilization--Southern
2 - Utilization--Western
3 - Human Nutrition
3 - Clothing and Housing
3 - Consumer and Food Economics
4 - Market Quality
4 - Transportation and Facilities
7 - Animal Husbandry
7 - Animal Disease and Parasite
12 - Crops
12 - Entomology

Economic Research Service (ERS)

4,5 - Marketing Economics
5 - Farm Production Economics
5 - Resource Development Economics
5 - Economic and Statistical Analysis
5 - Foreign Development and Trade Analysis
5 - Foreign Analysis Division

Other Services

4,5 - Farmer Cooperative Service (FCS)
4,5 - Statistical Reporting Service (SRS)
6 - Forest Service (FS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

3 - Rural Dwellings
6 - Forestry (Other than Forest Service)
7 - Beef Cattle
7 - Dairy
7 - Poultry
7 - Sheep and Wool
7 - Swine
7 - Cross Species and Miscellaneous Animal Research
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Citrus and Subtropical Fruit
10 - Deciduous Fruit and Tree Nut
10 - Potato
10 - Vegetable
10 - Florist, Nursery and Shade Tree
11 - Oilseeds and Peanut
11 - Sugar
13 - Tobacco

A copy of any of the reports may be requested from James F. Lankford, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

INTRODUCTION

This report deals with research directly related to the production, processing, distribution, and consumption of oilseeds and peanuts, and oilseed and peanut products.. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only oilseed and peanut problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organization unit reports of the several divisions.

The report is presented under three main headings: Farm Research; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. There is also a breaddown by problem areas as shown in the table of contents. For each area there is a statement of (1) the Problem, (2) USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) a summary of Progress during the past year on USDA and Cooperative Programs, and (4) a list of Publications resulting from USDA and Cooperative Programs.

Oilseed and peanut research is supported by (1) Federal funds appropriated to the research agencies of the U.S. Department of Agriculture, (2) Federal and State funds appropriated to the State Agricultural Experiment Stations, and (3) private funds allotted, largely by oilseed and peanut industries, to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service dealing with oilseeds and peanuts comprises investigations on breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology, and Agricultural Engineering Divisions. The work involves 64 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to improved methods and equipment for mill processing of oilseeds and peanuts; development of new and improved food, feed, industrial uses of oilseed and peanut products; and nutrient values of oilseeds and peanuts. It is carried out by the Eastern, Northern, Southern, and Western Utilization Research and Development Divisions; Consumer and Food Economics Research Division; and Human Nutrition Research Division. The work in these divisions involves 138 professional man-years of scientific effort.

Marketing and Economic Research is done in three services. Marketing research in the Agricultural Research Service dealing with oilseeds and peanuts is concerned primarily with the physical and biological aspects

of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. It is carried out by the Market Quality, and Transportation and Facilities Research Divisions. The oilseed and peanut research in these divisions involves 10 professional man-years of scientific effort. Economic research conducted in the Economic Research Service deals with marketing costs, margins, and efficiency; market potentials; market structure, practices, and competition; outlook and disuation; and supply, demand, and price. Research in cooperative marketing is conducted by the Farmers Cooperative Service. The oilseed and peanut research in these services involves 8 professional man-years of scientific effort.

Interrelationships among Department, State, and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry affected participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects, oilseed and peanut research is in progress in about half of the 53 State Agricultural Experiment Stations. The type of work to which the largest amount of effort is devoted includes breeding and genetics, culture, diseases, variety evaluation, insect control, weed control, agricultural engineering, utilization, and economics. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Industry's participation in oilseed and peanut research is carried out primarily by manufacturers of farm machinery and equipment, processors of intermediate products, such as unrefined vegetable oil, and by manufacturers of consumer products, such as shortening, margarine, and peanut butter.

Basic research done by the Department and States is utilized by industrial research laboratories in further development of improved products and equipment. Industry's cooperation in supporting oilseed and peanut research at Federal and State Stations has contributed greatly to its success.

I. FARM RESEARCH

SOYBEAN CULTURE, BREEDING AND GENETICS, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Since the maturity of soybean varieties is a function of the lengths of days and nights in which they grow, soybean varieties are adapted in maturity over relatively short distances from north to south. This adaptation to specific day lengths necessitates a large number of varieties to serve the soybean production areas of the United States. In addition, soil, diseases, and climatic conditions at time of maturity influence the adaptation of soybean varieties.

Soybeans are produced commercially in the United States for the oil and protein in their seeds and these two components are negatively correlated. This negative association necessitates separate breeding programs for oil and protein if maximum breeding progress in each is to be obtained. More precise research information is needed on the most efficient breeding procedures for improving oil and protein as well as yield and other agronomic characteristics; on why the maximum obtainable yields of soybeans are relatively low in comparison to other crops; on factors affecting the success and efficiency of strains of nodulating bacteria; on the disease organisms affecting soybeans and on the distribution, severity and damage caused by the many disease organisms affecting soybeans. There also is a need for the introduction, development or identification of sources of resistance to some of the important diseases such as stem canker and brown stem rot.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving geneticists, plant pathologists, physiologists and biochemists engaged in both basic studies and the application of known principles to the solution of growers' problems. Genetics and breeding research is conducted in cooperation with agricultural experiment stations at Gainesville, Florida; Urbana, Illinois; Lafayette, Indiana; Ames, Iowa; College Park, Maryland; Stoneville, Mississippi; Columbia, Missouri; and Raleigh, North Carolina. In addition, the evaluation of experimental selections from the genetics and breeding research is conducted in formal cooperation with the experiment stations at Auburn, Alabama; Fayetteville, Arkansas; Experiment, Georgia; Manhattan, Kansas; Lexington, Kentucky; Baton Rouge, Louisiana; E. Lansing, Michigan; St. Paul, Minnesota; Lincoln, Nebraska; Fargo, North Dakota; Columbus, Ohio; Stillwater, Oklahoma; Clemson, South Carolina; College Station, South Dakota; Knoxville, Tennessee; College Station, Texas; Blacksburg, Virginia; and Madison, Wisconsin; and in informal cooperation with experiment stations in other soybean producing states. Research on soybean diseases is conducted in cooperation with the agricultural experiment stations at Stoneville, Mississippi; Raleigh, North Carolina; Urbana, Illinois; Lafayette, Indiana; and Ames, Iowa.

The variety evaluation research is conducted with the same type of cooperation as that for genetics and breeding. Research on culture and physiology is conducted in cooperation with experiment stations at Urbana, Illinois; Lafayette, Indiana; Ames, Iowa; Stoneville, Mississippi; Columbia, Missouri; and at Beltsville, Maryland, and Brawley, California.

The Federal scientific effort devoted to research in this area totals 20.8 professional man-years. Of this number 8.6 is devoted to breeding and genetics; 6.0 to diseases; 1.7 to quality and variety evaluation; 3.8 to culture and physiology; and 0.7 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientists at the State Experiment Stations are engaged in basic and applied research in plant breeding and genetics, plant pathology, and agronomy. In many of the States, the research is conducted cooperatively with the Department. This research is continuing to provide useful information for the improvement of soybeans.

Soybean varieties have rather specific environmental requirements, hence many States are engaged in date of planting, rate of planting and row spacing studies. Other cultural studies concern rotations, seedbed preparation, late seeding following small grain harvest, environmental interactions with diseases and weed control.

Major breeding efforts are concentrated at a relatively few States but many States are testing the selections coming from these programs for local adaptation. The objectives of the breeding programs are improved resistance to diseases and cyst nematodes, high oil content, yield, and seed quality. A few States are interested in soybeans for use as forage. Genetic studies concern the effect of radiation on quantitative factors, the cytology of soybeans and related species, a search for various sterility and cross-pollination controlling factors, and factors contributing to yield. Biometrical studies are underway to evaluate selection methods, determine types of gene action, genetic correlation, and variation changes resulting from various methods of selection.

Illinois is evaluating soybean varieties and soybean products for human consumption. Missouri is conducting research on genetic and environmental factors which affect the quality of soybean seed for planting.

Diseases of soybean are being investigated through research at the State Stations and the U. S. Department of Agriculture cooperates in some phases of this program of research. (As more information is accumulated on the normal physiology of the soybean plant, the need for fundamental knowledge on the abnormal physiology, i.e. the pathology, becomes increasingly important.) In recognition of this, pathologists are conducting research on the biochemical basis for resistance, the physiology of parasitism, mechanisms of resistance to disease, and similar problems. In addition,

research is in progress to determine the essential histological and histochemical relationships in specific disease, to determine genetic relationships in certain pathogens with respect to variability and origin of virulent strains, and to determine epidemiological relationships that will be of value in developing effective controls.

A portion of the research of these scientists is directed toward the isolation of soybean germplasm resistant to disease, which can be used by geneticists and plant breeders to improve the crop. (A major recent finding in this respect was resistance to the soybean cyst nematode in a yellow coated form.) Other advances are being made in resistance to the root knot nematode, Phytophthora blight, Pythium root rot, and pod and stem blight. Recent findings on the role of leaf beetles in transmission of pod mottle virus indicates a degree of efficiency not previously known. Other scientistis are studying the pronounced synergistic effects with viruses such as mosaic and pod mottle. Two research projects are designed to provide information on pod and stem blight of soybeans which is a cause of much poor seed quality. Research is in progress on new forms and strains of the frogeye fungus so that effective controls can be developed for this disease. Several research projects are designed to determine the role of nematodes in the transmission of viruses of soybean. These are a few segments of the research program in progress at the State Stations on diseases of soybeans.

The total research effort on soybeans is approximately 17.9 professional man-years; of which - is for culture, 12.6 for breeding and genetics, 3.0 for diseases, and 2.3 for variety quality evaluation.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Genetics and Breeding

1. New varieties. One new variety, Bragg, was released in Florida, Georgia, North Carolina, and South Carolina in 1963. Bragg is resistant to several important diseases and is superior in yield and other agronomic characteristics to Jackson and other varieties grown in its area of adaptation.

Chippewa 64, developed by backcrossing Phytophthora resistance to the original Chippewa variety, was released in 1964 in the states of the north-central area where Chippewa is adapted. In the absence of phytophthora rot, Chippewa and Chippewa 64 yield the same, but Chippewa 64 is much superior to the original in areas where phytophthora rot is a production problem.

2. Association between black seedcoat and resistance to the cyst nematode. Intensive attempts to break the linkage between black seedcoat and resistance to the cyst nematode were apparently successful in 1963. The

desired types were obtained in three different programs involving three different varieties in backcrosses to the original resistant black-seeded Peking variety; namely, Scott in Missouri, Lee in North Carolina and Hill in Mississippi. The selections obtained from the Lee backcrosses should be satisfactory for commercial production, because selections from preceding backcrosses yield almost as much as Lee. Some of the selections from the Hill backcrosses also may be suitable for commercial production.

The small amounts of seed of the promising yellow-seeded resistant selections were increased in Puerto Rico in the winter of 1963-64 to provide sufficient seed for extensive field tests in 1964. If the resistance of the selections is confirmed in the cyst nematode infested area in 1964, the best one or two selections will be increased to the 15 or 20 bushel level in Puerto Rico in the winter of 1964-65. The resulting seed will be increased to the maximum level possible in the growing season of 1965 and released in 1966.

3. Soybean crossing. Difficulties in crossing soybeans and the very low amount of natural outcrossing have long limited the kind of breeding and genetics research that could be done with soybeans. Soybean breeders have searched for years for some method of increasing the natural crossing of soybeans to facilitate various breeding procedures. X-ray irradiation increased outcrossing from the usual amount (less than 0.5 percent) to as high as 6 or 8%. However, this was not considered adequate and in addition, genetics and breeding research was complicated by the mutations created by irradiation. Male sterile plants have been sought for many years, but in all cases reported to date, sterile soybean plants are both male and female sterile.

Over the past several years a high percentage of outcrossing has been observed to be associated with the tobacco ringspot virus which causes bud blight. An experiment was completed in North Carolina in 1963 which indicated that this virus may provide the means for large scale outcrossing of soybeans for experimental purposes. On plants artificially infected with the virus, 35% of the seed produced were from outcrosses; and on plants infected with the virus from seed transmission, 26% of the seed were from outcrosses. Plants resulting from crossed seed can be identified by genetic markers which permit the selection of hybrid plants for each cycle of the breeding system. This procedure is expected to permit soybean breeders to intermate soybeans on a large scale approaching what prevails naturally in a mixed population of corn or other cross-pollinated crops. Since the virus is transmitted by only about 80% of the seed, 20% of the plants in each generation will be free of the virus and can be used to establish lines for testing.

4. Inheritance of traits. Inheritance studies in 1963 demonstrated that resistance to the new race 2 of the fungus causing frogeye leafspot is conditioned by a single dominant gene. This gene is being transferred by backcrossing to a few adapted varieties in the event the new race of

frogeye proves to be as damaging as the original one.

Tolerance to high levels of phosphorus was demonstrated to be due to a single dominant gene. This gene has been transferred to two adapted varieties to provide tools for physiological research on the response to phosphorus. That is, a variety receiving the gene will be essentially the same as the original variety except that it will be tolerant to high levels of phosphorus whereas the original is intolerant. Differences in performance of the two isolines therefore can be safely attributed to differences in response to phosphorus.

B. Diseases.

1. Disease distribution. Brown stem rot was found for the first time in Delaware and Maryland in 1963 and was reported for the first time in North Carolina and Virginia in 1962. The disease can no longer be considered a disease of the north-central area and probably is now distributed throughout the soybean producing area. It is noted for its build-up in the soil when soybeans are grown continuously or in alternate years on the same field. Once it is present in a concentrated production area such as in Delaware and Maryland, it can be expected to increase in future years. The disease will be watched carefully in 1964 and if it is found to be widespread and severe in Delaware and Maryland as in 1963, increased breeding emphasis will be given to it. No known source of complete resistance to the disease is available, but promising materials with a low level of susceptibility have been developed in Illinois.

2. Viruses. In North Carolina the bean pod mottle virus was found to be transmitted by the bean leaf beetle, a common insect in soybean fields. This observation plus the interaction between bean pod mottle virus and soybean mosaic reported in the 1962 report make these two viruses much more important than they have been considered in the past. Soybean mosaic is seed transmitted and a small amount of it can be found in almost any soybean field. If mosaic infected plants are infected with the pod mottle virus by the bean leaf beetle, severe damage results. Thus two viruses, neither of which have been considered very important individually, constitute a disease complex that will be watched carefully in future years.

3. New diseases. Some progress was made in 1963 in clarifying the complex of bacteria found in soybeans. One species of Corynebacterium was found to be pathogenic on soybeans and to produce a disease identified as soybean wilt. This disease was prevalent on some soybean varieties in Iowa in 1963 and caused death of some of the plants as early as July. The disease also was observed in about half of the commercial fields in northern Iowa.

A second bacterium differing distinctly from the one causing wilt was consistently isolated from plants resulting from lots of seed showing poor quality and extension of the hilum. The bacterium appears to grow extensively in the vascular system of soybean plants and under some

conditions causes a reduction in the flow of water to the extent that wilting results. However, the most conspicuous symptom of the disease is poor seed quality and extension of the hilum to large areas of the seedcoat.

A third species of bacteria which is soil borne produces a leafspot of soybeans identified as chocolate spot which is similar in appearance to bacterial blight and brown spot diseases.

A fourth bacterium, Bacillus subtilis, apparently is associated with the sensitive response of soybeans to high levels of phosphorus. In sensitive varieties, high levels of the bacterium were associated with chlorosis and necrosis of the leaves and with the breakdown of the roots characteristic of the sensitive response to high levels of phosphorus. In contrast, tolerant varieties supported much lower populations of the bacterium.

4. Association between soybean diseases. In Iowa, experiments indicated that the bacteria causing soybean wilt and the fungus causing stem canker are associated in producing disease symptoms. In northern Iowa the highest incidence of wilt and of stem canker were observed in the same fields and both organisms were isolated from the cankers on the soybean stems. Mixtures of the bacteria and fungus applied to soybean stems produced cankers even without wounding the plant. Wounding was necessary to produce the disease when the stem canker fungus alone was applied.

5. The effect of rotation on disease development. In Iowa, soybeans were evaluated in an area heavily infested with brown stem rot following 1, 2, and 4 years of corn. The yields were as follows: after one year of corn, 29.8 bushels per acre; two years, 34.8 bushels; four years, 37.3 bushels. Soybeans in a continuous rotation of soybeans produce 24.9 bushels. Only 10% of the plants following 4 years of corn were infected but this increased to 100% in the succeeding crop of soybeans, although the infection occurred later and the yields were higher than in the continuous soybean rotation.

C. Quality and variety evaluation. The evaluation of the effect of increasing protein by breeding on the methionine content of the protein was continued in 1963. The results again indicated that the methionine content of the protein is not being reduced in breeding for high total protein.

Approximately 16,000 samples of seed from all aspects of the research program were analyzed for oil and protein content.

D. Culture and physiology.

1. Response of soybeans to nutrients. In a field experiment in Iowa, the response of a phosphorus sensitive variety and a phosphorus tolerant variety to high levels of calcium chloride was similar to their response to high levels of phosphorus observed previously. That is, the phosphorus

tolerant variety, Adams, was not affected by rates of calcium chloride up to 4,000 pounds per acre, whereas the yields of the sensitive variety, Ford, decreased rapidly with added increments of calcium chloride above 1,000 pounds per acre. In greenhouse experiments at Beltsville, a given amount of chloride from various sources gave the same type of response on sensitive varieties indicating that the effect of chloride is specific rather than being an interaction between chloride and other nutrients.

Phosphorus sensitive varieties take up more phosphorus than phosphorus tolerant varieties and all parts of the plants of sensitive varieties contain more phosphorus than those of tolerant varieties. In contrast, the roots of chloride sensitive and chloride tolerant plants apparently take up chloride at the same rate, since they contain essentially the same amount. However, the stems of sensitive plants contain substantially more chloride than the stems of tolerant plants and the leaves of sensitive plants contain much more chloride than the leaves of tolerant plants. Thus two control mechanisms appear to exist, but preliminary evidence indicates that at least some varieties tolerant to high levels of phosphorus are also tolerant to high levels of chloride and that some varieties that are sensitive to high levels of phosphorus are sensitive to high levels of chloride. The interrelationship involved in the responses to phosphorus and chloride will be explored further in 1964.

In Illinois the adverse effect of high phosphorus on sensitive varieties was corrected by adding high levels of nitrogen, thus demonstrating an interaction between two nutrients in conditioning a response previously attributed to one.

2. Nodulation. In Florida, 104 strains of nodulating bacteria and three commercial inocula were tested on the new Hardee variety in soil that contained few nodulating bacteria. The results indicated that a surprisingly large number, approximately 30%, of the strains were ineffective on Hardee and that some of the effective strains were much superior to others. Yields ranged from 14 to 46 bushels per acre. Two of the commercial inocula produced in the northern part of the United States were less effective than the commercial inoculum produced in Florida. Yields resulting from the two northern inocula were 30 and 35 bushels per acre whereas the yield from the local inoculum was 40 bushels per acre. The results clearly indicate the importance of nodulating bacteria in the development and production of soybean varieties. All of the experimental areas and most of the commercial acreage in Florida have been inoculated with the local product. Hardee is well adapted to the strains in the local product and its performance was sufficiently good to justify its release as a variety. Had either of the two northern inocula been used as was the local product, the performance of Hardee as an experimental selection would not have been sufficiently good to justify its release as a variety.

In Maryland and Iowa, attempts to develop a satisfactory method of inoculating soybean seed to be planted in soils that already contain the

nodulating bacteria were continued. The results again indicated a very low level of success of inoculum applied in the usual commercial fashion. The results in Maryland were quite encouraging in that inoculum applied to the seed at about 25 times the normal rate with a sticking agent was as successful as inoculum drilled in with the seed at much higher rates. Strains differed significantly in their rate of success, indicating the possibility of selecting strains with increased chances of success when used as inoculum.

In Iowa, the success of the inoculum was proportional to the amount applied, with the inoculum applied 6 to 8 days after planting and watered in being the most successful. The results suggested that the bacteria applied as inoculum died at a rapid rate. This is believed to be associated with delayed germination due to cold weather following planting, since the success of inoculum on some small seeded legumes has been demonstrated to be proportional to speed of germination. In general the results in 1963 were encouraging in the attempt to develop a satisfactory method of introducing superior strains of nodulating bacteria into soils that have previously grown soybeans.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

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OILSEED CULTURE, BREEDING, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. Increased acreage of safflower with lower price for oil has increased the importance of more efficient production through higher yield of seed, thinner hull with higher oil in the seed and higher protein of the meal. Breeding lines with these characteristics are available, and their desirable qualities need to be combined in improved varieties. Better cultural methods resulting in improved stand establishment and weed control are urgently needed in the Central Great Plains.

For peanuts, more precise information is needed on: (1) the nature and control of diseases with special emphasis on mold toxicity and soil borne diseases; (2) the physiology of the plant, mineral nutrition, and environmental factors affecting growth, and flowering and fruiting; (3) breeding behavior of the crop; and (4) identifying and measuring characteristics of peanuts associated with quality for specific end uses. Improved varieties with higher yield, resistance to diseases and insects, increased market acceptability, and enhanced nutritional and keeping properties are urgently needed.

The most urgent problem in flax is the development of varieties resistant to new races of rust that may arise through mutation. A thorough evaluation is needed of all possible sources of new resistance genes. Pasmo, and to a lesser extent aster yellows and crinkle, remain occasionally destructive diseases. Improved varieties with higher yield, higher oil content, and greater resistance to disease are needed. There is urgent need for further information on physiology, chemistry of the oil, and the nature of the hypersensitive type of disease resistance.

Improved inbred lines of castorbean that combine well are needed to produce F_1 hybrids with high yield of seed and oil, disease and lodging resistance, and that retain their seed after ripening of the capsule. Basic genetic research is required in breeding improved inbred lines.

The urgent need in sesame production is varieties that will produce high yields of good quality seed and are adapted to mechanization. Research is required to produce varieties with indehiscent capsules that have higher yield and thresh more easily or semi-dehiscent varieties with strong placenta attachment capable of retaining the seed until it may be combined.

Limiting factors in sunflower production are the control of insects and diseases. Breeding lines vary widely in oil content and fatty acid composition of the oil. Improved inbred lines are needed for successful production of F_1 hybrids.

Methods are needed, either chemically to keep tung trees dormant to avoid spring frosts, nutritionally or culturally to make trees more cold hardy, or through breeding to find or develop more cold hardy or later blooming clones. In some years, the disease Mycosphaerella leaf spot defoliates trees early reducing oil content. Control for this disease, either chemical or through breeding, is urgently needed. More information on spacing, nutrition, cultural practices, and variety testing is needed to enable more consistent and higher production at less cost.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, pathologists, biochemists, physiologists, agronomists, and horticulturists engaged in both basic and applied research leading to the solution of growers' problems. Safflower breeding, disease, and cultural research is being carried on in cooperation with the California, Utah, Arizona, and Nebraska Agricultural Experiment Stations and at Beltsville, Maryland. Peanut breeding and variety evaluation research and peanut disease investigations are cooperative with the Georgia Experiment Stations. Disease, culture, seed physiology, and variety evaluation research are cooperative with the Alabama Experiment Station. Peanut disease and variety evaluation research are cooperative with the Virginia Experiment Station. Peanut variety evaluation and seed physiology research are carried on at Beltsville, Maryland. Peanut rust and variety and strain adaptation research are carried on at Mayaguez, Puerto Rico. Peanut research is being conducted under 3 5-year PL 480 contracts. One in India, ($89,735, rupee equivalent), covers range of genetic variability in U.S. and India's diverse peanut germ plasm. Another in India, ($31,915, rupee equivalent), involves physiology of cell particulates. The third in Israel ($129,250, Israeli pounds equivalent), is a study of the biology of the fungus Aspergillus flavus as it affects peanuts. Flax research is conducted cooperatively with the Minnesota, North Dakota, and South Dakota Agricultural Experiment Stations, and at the Southwestern Irrigation Field Station, Brawley, California. Castorbean breeding and genetics, disease control, and cultural trials are conducted in cooperation with the California, Texas, and Mississippi Agricultural Experiment Stations, and at Beltsville, Maryland. Sesame research is conducted in cooperation with the Texas and Mississippi Agricultural Experiment Stations and at Beltsville, Maryland. A limited program of sunflower research is conducted in cooperation with the Texas Agricultural Experiment Station. The Department has a continuing long-term program of tung research carried on at one central field location at Bogalusa, Louisiana, with a field laboratory at Cairo, Georgia. The work is cooperative with the experiment stations of Mississippi and Louisiana. Much of the field work and experimental plantings are at the Mississippi Experimental Tung Farm, Poplarville, Mississippi.

The Federal scientific effort devoted to research in this area totals 33.6 professional man-years. Of this number 9.9 are devoted to genetics and breeding; 8.2 to diseases; 4.2 to variety evaluation; and 11.3 to culture.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientists at the State Experiment Stations are engaged in basic and applied research in breeding, agronomy, plant pathology, and chemistry. In many of the States, the research is conducted cooperatively with the Department. This research is continuing to provide useful fundamental information for the improvement of peanuts, flax, sesame, castor beans and sunflowers.

Research on peanuts includes studies on the rates of fertilizers and irrigation. In breeding the objectives are yield, disease and insect resistance, local adaptation, and trueness to market types. Genetic studies involve the collection of wild species, their classification, and eventual crossing. Irradiation is also being used to produce new mutant types. Studies on quality concern curing, temperature-time-moisture relationships on keeping quality, and susceptibility of varieties to rancidity. The effects of variety, maturity and curing practice on quality is being determined.

In flax breeding the objectives are resistance to wilt and rust, tolerance to pasmo, quantity and quality of oil, and yield. Local adaption of varieties is determined in each of the States working on flax as well as local fertility and seeding practices. The genetics of rust resistance and association with other desired characteristics is being studied.

Several States are determining local adaptation of safflower varieties and breeding for yield, disease resistance, and high oil content. They also are determining the best practices under irrigation and dryland. Rate of seeding, spacing, seedbed preparation and weed control are under study.

The potential of sesame, sunflowers and castorbeans is being determined in a number of States. Varieties with high yield, local adaptation, resistance to diseases, and high oil content are sought. Nutrient requirements of these crops and better weed control methods are being studied. Ease of harvest is a major objective in sesame and castorbeans.

Scientists at the State Colleges and Universities are conducting research on all of the primary disease problems of oilseed crops. These include such diverse plant crops as castor bean, sesame, peanuts, flax, safflower, tung, and sunflower. Many of the diseases of these crops contribute heavily to low yields and poor quality, and in some instances, are a major limiting factor in their production. Through some research projects, State Station scientists are involved in the isolation of germplasm resistant to specific diseases, which can be used by plant breeders and others for improvement of these crops.

Research on diseases of flax involve studies on the destructive rust and seedling blight problems. The biochemical specifics of resistance in flax to rust is providing new knowledge on metabolic pathways in the disease process, on enzymatic patents such as those involved in epoxy-stearic acid synthesis, and on other areas of disease physiology. Studies are also being conducted on the use of chemicals in the control of flaxrust. Seedling

blight of flax is being investigated with emphasis being placed on the role of crop sequence and residues in control of the disease. A few research projects are designed to provide new knowledge on diseases of safflower, sunflower, and sesame, such as fusarial wilt, rust, bacterial blight, Verticillium wilt, and root rots. Castorbean diseases are being studied at several locations. New findings on Alternaria leaf spot of castorbean have demonstrated the breakdown of resistance in new varieties, and thus provides a better basis for eventually obtaining effective control of this disease. Seed diseases and seedling blights of castorbean are also being investigated.

Scientists at the State Stations are also providing leadership in research on the disease problems involved in the culture, harvesting, and processing of peanuts. Several scientists are concerned with the role of nematodes in diseases of this crop. Through one project special attention is given to the cyst-forming species which have been discovered in certain peanut areas in recent years. Other investigations on nemas in peanuts are designed to provide knowledge on the root knot problem, the interaction of nemas and other disease agents, their role in the black hull problem, and the use of chemical and biological systems for their control.

A pressing pathological-microbiological problem in peanut culture, both in this country and in other parts of the world where this product is produced or used, is that of mycotoxins and, specifically, aflatoxins. Scientists at eight of the State Stations have concentrated their efforts on this problem facing the peanut industry and are providing significant contributions through their leadership in this research. Other government agencies, including the Department of Agriculture, and industry cooperate in some phases of this work. Progress in this research has recently been summarized in joint meetings with all institutions and agencies concerned.

The total research effort on oilseeds is approximately 14.9 professional man-years; of which 0.6 is for culture, 8.4 for breeding, and 5.5 for diseases, and 0.4 for variety evaluation.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

A. Breeding and Genetics

1. Safflower. New safflower varieties. Two lines of safflower with promise as commercial varieties are being given final testing before release. A0104 is a normal hull variety, with slightly higher yield than Gila and higher oil. It is adapted to Arizona, the Central Great Plains, and California. The second promising line, 12417, is a striped hull type that has half as much hull as Gila, averages 10 percent higher in oil and considerably higher in protein in the meal. As an average of 5 trials in Arizona A0104 averaged 400 pounds more seed, 3.4 percent higher in oil, and 289 pounds more oil per acre than Gila. Line 12417 produced 133 pounds more seed, 11.3 percent higher oil, and 492 pounds more oil per acre than Gila. Preliminary tests indicate the increases in oil percentage are the result

of reducing hull percentage rather than a genetic advance in oil content of the meat.

2. Peanut. Genetic marker expedites peanut breeding and genetic studies. In studies on extent of natural crossing in peanuts at Tifton, Georgia, a minimum of 15 percent was demonstrated between the genetic marker Krinkle and a recent peanut introduction in 1962, a season when the general level of natural crossing varied from about 1 to 2 percent.

Puerto Rico may speed peanut variety improvement. Preliminary plantings and observations at the Federal Experiment Station, Mayaguez, Puerto Rico, indicate successful increase of breeding lines of peanuts during the winter might be possible. Full confirmation of this would mean that the time between the making of a cross and the release to growers of an improved variety developed therefrom could be shortened by fully 40 percent, or 5 to 6 years, provided full advantage could be taken of the Crops Research Division facilities at Mayaguez.

3. Flax. Breeding for rust resistance. A few flax introductions had either new rust conditioning genes or unusual combinations of genes. Several backcrossed Bison lines that are multigenic for rust resistance ($\underline{L}\ \underline{M}^3\underline{N}^1$) showed promise in preliminary tests.

Breeding improved varieties for Southwestern States. Plant progenies of Caldwell, the new variety released in Texas, were tested for their reaction to 4 virulent North American races of rust. Thirty lines were pure for some degree of resistance to all 4 races and are being increased during 1963-64. The variety Dunes, a new high-yielding, wilt-resistant, winter-type selected from B-5128 x Punjab 47^3, is being released for production in the irrigated areas of the Southwest. It is outstanding in oil content.

4. Castorbean. Hybrid castorbeans. Hybrids are now generally showing superiority over commercial inbred varieties in performance tests. At Lubbock, Texas, the best hybrids were significantly higher in yield than the commercial inbreds. At Davis, the highest yielding hybrid was 7 percent higher than the highest yielding inbred. At Shafter, under conditions of nutritional stress, the highest yielding hybrid was 30 percent higher than the highest inbred.

Improved pistillate castorbean lines released. Current commercial production of F_1 hybrid planting seed requires roguing of sixty percent or more of male plants from the female rows. The first increase of a strain called CNES-1 which provides a unique sex mechanism for the production of F_1 hybrid planting seed was grown in the Imperial Valley of California in 1963. The essentials of the CNES-1 sex mechanism consist of genotypes containing both the environmentally insensitive N-pistillate gene f for pistillate flowers along the entire raceme axis and environmentally sensitive genes for interspersed staminate flowers. Reproduction is secured at a location such as the Imperial Valley where there is penetrance of the genes for interspersed

staminate flowers. Hybrid seed is produced where there is non-penetrance or it is at a low frequency, as in the Central Valley of California. In Texas, TSPR 10, an S-pistillate strain reselected for indehiscence from TSP 10, produced 90 percent female plants.

Inheritance of resistance to capsule drop. Additional information supports the previous hypothesis that resistance is controlled by two pairs of factors with no dominance effects. Variation for important traits such as resistance to Alternaria capsule mold, indehiscence, and high oil is present in the capsule drop resistant lines. Selection for resistance to capsule drop has resulted in lines also possessing resistance to Alternaria capsule mold. At Davis, California, 3 out of 30 Mississippi capsule drop resistant lines were not significantly different from a high oil line.

Inheritance of oil content. The frequency of high oil F_3 and F_4 lines suggests that the parents differed by only a few major genes for oil content and high oil percentage may be transferred easily to commercial varieties.

5. Sesame. A new combine-type sesame. Baco, a new combine-type sesame, has been released in Texas. This is the best of several indehiscent lines with the highest yield and comparative high percentage of threshability. Threshability has been increased from less than 50% in the primitive type to more than 95% in papershell types. In addition, disease resistance and general agronomic adaptation has been incorporated into these combine types.

Inheritance of resistance to both known races of Pseudomonas sesami. Resistance to Race 1 is conditioned primarily by a major recessive gene found in Early Russian and Margo. Both appear to supply a minor dominant gene which assists in conditioning resistance to this race. Early Russian contributes a major recessive gene and a minor gene complex which conditions resistance to Race 2. This major recessive gene and the minor gene complex are different from those in Early Russian that are responsible for resistance to Race 1.

Breeding for high expression of placenta attachment. SI 175, a strain of dehiscent sesame that is medium-early and resistant to bacterial leaf spot, Race 2, has a strong placenta attachment. The preliminary yield record of this strain indicates that it may excel Margo and Oro in seed production.

6. Sunflower. Self-incompatability. Further studies on self-incompatability of S-37-388 indicate this important character is influenced by both genetics and environment and careful balancing of these two factors will be required to retain sufficient self-compatability to produce inbred seed and still retain sufficient self-incompatability to make the line useful in the production of F_1 hybrids.

7. Tung. Breeding for late blossoming and cold hardiness. An airplane survey of commercial Louisiana and Mississippi tung orchards during 1963 located more than 30 trees that bloomed from more than 1 to 3 weeks later than the

commercial Isabel variety. The late blooming trees tended to be male but one, M-232, had both male and female flowers. Oil content of the late blooming selections varied widely but the most promising ones had almost 25 percent oil. Late blooming selections continue to be hybridized and progeny evaluated for horticultural characters.

Breeding for flowering habit. Attempts to introduce the Aleurites montana habit of blooming on current season's growth into the more hardy and commercially grown A. fordii was continued. In 1963, 50 hybrid seedlings were found to have the desired A. montana flowering habit.

Breeding for oil content. Fruit character related to yield of oil indicates that high percent oil per fruit is generally associated with a combination of a high ratio of nut to hull and a high percent oil in nut. The characters must be combined with a high yield of nuts per tree to result in high acre yields.

Breeding for disease resistance. Progeny from some open pollinated Mycosphaerella resistant trees tended to lack parental resistance in varying degrees whereas progeny from others tended to have high and uniform resistance. Two gene systems controlling Mycosphaerella resistance are indicated.

B. Diseases

1. Safflower. Phytophthora root rot. A number of sources of resistance have been found in commercial varieties and introductions. Resistance appears dominant in the F_1 and to be simply inherited in the F_2. Resistance in the greenhouse is associated with field resistance.

Rust. A number of seed treating agents gave practical but not complete control of seed-borne rust under field conditions. Resulting stands were adequate, but enough rusted plants remained to cause rust on growing plants. None of the treatment materials gave lasting chemotherapeutic action either as a protectant or as an eradicant.

Fusarium. The Fusarium wilt resistance of the variety Nebraska 6 is being transferred to the variety Gila by backcrossing. Reaction and segregation for wilt resistance in the F_1, the F_2, and the 1st backcross indicated resistance to be dominant.

Peanut. Rhizoctonia solani and a Pythium species appear to be involved in peanut pod rot. Evidence indicates that both a Pythium sp. and R. solani are important pathogens of peanut pod rot in Virginia. Neither of these fungi has been found associated with freshly dug sound peanut pods. Present evidence indicates that application of landplaster at rates of 1000 to 1500 pounds per acre might be helpful in suppressing pod rot and increasing yield and market quality of pods. Two chemicals show evidence of suppressing incidence and severity of pod rot under certain conditions. Permanent deep burial of surface trash in initial land preparation was helpful also when

used in conjunction with certain other procedures.

Kind and distribution of organic litter in soil influence soilborne diseases under field conditions. The kind and distribution of organic litter in the soil were critical factors at different locations in a continuing study of the effects of the amount, kind and distribution of crop litter in the soil on incidence and severity of soilborne diseases and yield and market quality of peanuts produced on two widely different soils in South Georgia. Striking differences in yield and appearance of peanut pods were obtained following respective crops in the rotation.

Spraying the soil at planting helps to reduce losses from peanut leafspots. Where peanuts follow peanuts, increases in yield have been obtained in Georgia by spraying the soil with fungicides at planting time or soon after seedling emergence to help reduce losses due to peanut leafspots.

3. Flax. Rust. The new flax rust race 300 was found on susceptible varieties at several locations in North Dakota in 1963. Another new rust race that attacks the L^4 gene of Kenya was found in all fields of DeOro that were surveyed in North Dakota. There have been no new races detected in North America that attack the L^6, M^3, P^3 or N^1 resistance genes. The latter gene conditions resistance in all presently grown commercial varieties.

4. Castorbean. Capsule drop. Evidence has been obtained that at least 2 genetic factors control resistance to capsule drop. One is found in Baker 296 and both in MW-1. Both varieties have been used as parents in crosses with commercial varieties or improved breeding lines. There is good evidence that varieties resistant to capsule drop with high yield, good seed size, high oil content, and good agronomic type will be developed. A high degree of association between resistance to capsule drop and Alternaria capsule mold was found.

Botrytis capsule mold. Capsule pericarp tissue of varieties susceptible to Botrytis capsule mold was found to contain a larger number and more highly concentrated phenols than resistant varieties. This was the basis for reaction of tissue to vanillin - H_2SO_4 and $FeCl_3$ - $K_3Fe(CN)_6$ being indicative of resistance. Capsule pericarp tissue of susceptible varieties contained more soluble pectin than resistant varieties. The resistant tissue had a higher content of calcium and magnesium and a lower content of sodium and potassium than susceptible tissue. The soluble pectin and cation content explains the reaction of resistant and susceptible tissue to the hydrolytic enzymes.

5. Sesame. Resistance to bacterial leaf spot. Growth room studies of the effects of light and nitrogen on susceptibility of sesame to Pseudomonas and Xanthomonas were continued. Source of N had only a small effect on Pseudomonas but a marked effect on Xanthomonas, confirming results of previous tests. However, the effect of N source varied with the variety in the case of Xanthomonas but not with Pseudomonas. As in previous tests with 14 hours

light per day, with low N Venezuela 51 was susceptible to both organisms and Early Russian was resistant. With high N both varieties were equally susceptible to both bacteria. Both varieties were resistant to Xanthomonas with low N and continuous light.

6. Sunflower. Rust. A second and possibly a third race of Puccinia helianthi appeared at College Station, Texas, in 1963. The hybrid T56002 which has continued to be resistant to leaf rust at all locations was susceptible to stem rust at Fargo, North Dakota.

7. Tung. Angular leaf spot (Mycosphaerella aleuritidis). Orchard studies confirmed earlier observations that primary infection by Mycosphaerella occurs mainly on the dorsal tung leaf surface. Correlation of soil mineral status and degree of infection reaffirmed earlier reports that either low soil calcium on low pH caused increased leaf spot severity. Orchard sanitation experiments which augmented and confirmed earlier studies showed significantly fewer primary infections developed on seedlings grown in cultivated than in uncultivated areas. A dinitro oil ground spray did not enhance the effectiveness of cultivation as a control measure.

C. Varietal Evaluation

1. Safflower. Two new breeding lines tested during the past year are being considered for potential release. The most promising of these appears to be 12417, a striped hull line with high yield, low hull percentage and high oil content. A0104 is a normal hull line with better yield and oil content than present commercial varieties. Seed of these two lines is being increased in anticipation of possible release.

2. Peanut. Florigiant continues to show high yield potential and wide adaptation. Results of cooperative regional peanut variety tests in 5 States in 1963 confirm previous findings that Florigiant and related advanced breeding lines from Florida have an outstanding yield potential and a wide range of adaptation extending from Virginia to Florida.

Recent peanut introductions from foreign countries show promise. Of more than 900 recent peanut introductions or selections therefrom under agronomic evaluation in cooperative replicated tests in Georgia, Alabama, and New Mexico in 1963, 12 to 15 percent outyielded standard commercial check varieties.

Seed of varieties of peanuts differ in chemical composition. Results of chemical analysis of mature seed of a wide range of types and varieties of peanuts indicate that (1) a strong negative correlation exists between oil and protein; (2) some varieties are higher in oil than others; and (3) delayed planting at Tifton, Georgia tends to decrease yield, lower oil, and increase protein content. Preliminary results indicate that a wide variation exists in fatty acid composition of oil of mature seed of different types and varieties of peanuts, and that the fatty acid composition of

apparently mature seed can be influenced considerably by the conditions under which the seed are grown.

3. Flax. The variety situation in flax is dominated by the threat of a new race of rust, race 300, first found in Canada in 1962 and in the United States in 1963. Marine, the most popular variety in the North Central States, is susceptible, as well as Sheyenne, Arny, and several other varieties of lesser importance. B5128, Bolley, Redwood, and a few other minor varieties are resistant. Growers have been warned to prevent serious losses in 1964 by switching to resistant varieties.

New wilt-resistant variety for the Southwest. Dunes, a new wilt-resistant variety, with excellent yield and oil content as well as good wilt resistance is being increased and will be released in California. Because of its superior yield and oil content it will replace New River where wilt has been a problem, and may replace Imperial on non-wilt fields because of its high oil.

4. Castorbean. A new pistillate breeding line. CNES-1, has been released to breeders. This line carries the ff gene pair for pistillateness, so that it may be used as a female parent in the production of F_1 hybrids with little or no rogueing to remove normal monoecious plants. When grown under certain environmental conditions, environmental sensitive genes cause the development of interspersed male flowers permitting the line to be maintained as an inbred. The environmental factors responsible for development of the interspersed male flowers are not known, but locations where these conditions exist are known.

5. Sesame. New combine variety. Baco, an indehiscent variety, is being released to growers. While the yield of this variety is not expected to equal that of the best dehiscent varieties, the elimination of considerable hand labor in harvesting may favor its acceptance by growers.

6. Sunflower. Yield trials. The rust resistant experimental hybrid T56002 was outstanding at most locations; its mean yields were approximately 30% higher than the best of the varieties and hybrids with which it was compared. Parental lines of this hybrid are under increase by the Texas, Minnesota and North Dakota Stations. The large-seeded commercial hybrids, NK hybrid 1 and NK hybrid 2, were outstanding at Stoneville, Mississippi, and North Carolina locations where rust reaction was not a factor in determining yield. Among the introduced varieties, seed of Peredovik, Smena, VNIIMK 89.31 and VNIIMK 16.46 are superior in oil content. The high-oil varieties do not appear adapted to the confectionery or birdfeed trades and are not likely to be produced domestically unless a market develops for sunflower. Linoleic acid content of the oil, as measured by iodine value, was high only at northern or high altitude locations where cool temperatures prevailed during seed development.

7. Tung. Twenty-three clones having potential late blooming, as well as high oil content, disease resistance, and other desirable horticultural

characteristics are being propagated at Bogalusa for systematic evaluation. Extremely low temperatures in the winters of 1961-62 and 1962-63 subjected tung trees in the tung belt to rigorous natural selection for winter hardiness. In a commercial northern Florida orchard, trees of the LaCrosse variety particularly were badly damaged and those of the Folsom variety little damaged during the winter of 1962-63.

D. Culture and Physiology

1. Safflower. Date of planting. A hard freeze, in January at Mesa, Arizona, severely injured Gila planted in November, but only a few plants of A0104 were injured. When planted at 16 or 32 seeds per foot of row the plants had grown out of the rosette stage and were subject to greater freezing injury. Later plantings were not so severely injured. In Western Nebraska, during the dry season of 1963, early planting (April 25 to May 10) produced the highest yields of seed at 3 to 7 plants per square foot.

Fertilizer and irrigation trials. Nitrogen fertilizer at 100 pounds N per acre applied 1/3 preplant, 1/3 in March, and 1/3 in April gave the highest yield of seed in Arizona. Biweekly irrigation resulted in higher yield than weekly or triweekly irrigation in Arizona. When the final irrigation was given to safflower on May 20, May 30, or June 11, yields of 2795, 3195, and 3594 pounds per acre were obtained in Arizona. The increase in seed yield from later irrigation was valued at several times the cost of irrigation.

Weed control. Hand weeding in commercial fields in Arizona gave an average increase of 984 pounds of seed per acre and indicates the considerable damage caused by weeds. In Western Nebraska timely use of the rotary hoe resulted in satisfactory weed control, but did not increase seed yield appreciably because of drought.

2. Peanut. Close rows failed to increase peanut yields appreciably in Alabama. A 4-year summary of the results of planting Virginia Bunch 67, Early Runner, and Virginia Runner G26 at different drill and row spacings on beds 36 inches apart at Headland, Alabama, indicates no yield or market grade advantage for the runner varieties and only a modest increase in yield for Virginia Bunch 67 when grown in rows as close as 24 inches as compared with rows 36 inches apart.

3. Flax. Fertilizer trials. Nitrogen fertilizer applied at rates of 40 and 80 pounds N per acre in West Central Minnesota was found to increase the seed yield of 5 flax varieties an average of 98 and 126 pounds per acre over a 3-year period. In this same study, the application of 4 oz. per acre of MCP to control broad-leafed weeds resulted in an average increase of 62 pounds of seed per acre. In contrast, the application of 4 oz. of MCP and 12 oz. of Dalapon per acre caused an average decrease of 25 pounds of seed per acre compared to the weedy check. Applications of nitrogen caused an increase in seed protein, but a marked decrease of oil content and oil

quality in the seed. The best combination of the three variables in this study, was the application of 40 pounds of nitrogen and 4 oz. of MCP per acre to Arny flax. This combination averaged 1,233 pounds per acre over a 3-year period, as compared to 1,004 pounds from unfertilized, unsprayed Arny, or 823 pounds from the check plots of Marine.

Basic physiology of the flax plant. Evidence was obtained that application of nitrogen to flax produces effects closely associated with oil synthesis. Studies have shown that production of oil content and oil quality are inversely correlated with nitrogen level in the soil. Determination of fatty acid composition of oil produced in controlled environments showed that linoleic and linolenic acids per 1,000 seeds are decreased at high levels of N.

4. Castorbean. Irrigation. Data from 8 irrigation treatments, varying time and number of irrigations, showed that as few as 3 irrigations could produce maximum yields in Texas. In treatments consisting of one irrigation, highest yields resulted from an application 20 days later blooming of the first raceme. In those consisting of two irrigations, applications 20 and 10 days after blooming of the first and second raceme, respectively, resulted in the highest yields.

Capsule drop. The incidence of capsule drop increases considerably during wet weather in late fall. Data from date of harvesting experiments conducted over a 3-year period in Mississippi indicate chemical desiccation and harvesting in early fall is a possible method of growing varieties susceptible to capsule drop in this area.

5. Sesame. Direct combining of indehiscent sesame. Three lines of indehiscent sesame were grown on a field scale in Texas and harvested by direct combining. Yields of clean seed ranged from 438 to 634 pounds per acre. Ground losses in combining were estimated at 7 to 10 percent which compares favorably with losses from harvesting dehiscent varieties. The highest yielding of these lines has been named Baco and released to growers.

6. Tung. A low temperature of 7°F. occurred widely throughout the tung belt in December 1962 and again in January 1963. The overall effect was a crop reduction of about 50 percent of a full crop. Loss of trees has greatly reduced the crop potential but the most extensive replanting program in the history of the domestic tung industry is taking place in the spring of 1964.

Tree spacing. The early advantage of greater yield per acre from close-planted trees is eventually overcome 9 years after planting by more widely spaced trees. Studies will continue to determine whether the early advantage of close planting will be counterbalanced by a more rapid decrease in yield from these trees as they age.

Soil moisture. A soil moisture level as low as 4 inches of water during the period of oil formation did not reduce yield but did reduce the oil content of the fruit.

Dormancy. Studies of factors associated with induction and breaking of rest in tung continued. After shoot growth is complete in mid-summer, trees respond to complete defoliation by putting out new leaves and flowers. As fall advances, defoliation becomes less effective in forcing new growth. When defoliation no longer forces growth, descaling of buds induces flowering. Bud scales apparently take over the inhibitory function of leaves as fall progresses. A technique of systematic defoliation, cold storage, and forcing of tung shoots was devised to screen selections in the laboratory for inherent late bud break and save years of orchard tests.

Growth regulators. Seventeen chemicals tested on excised terminals have shown some effectiveness to delay blossom bud opening. The most effective one held the buds dormant for more than 3 weeks longer than untreated buds when both were subjected to optimum forcing correlation.

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WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on oilseeds and peanuts.

USDA AND COOPERATIVE PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross commodity in nature. The total weed control program involves 57.5 professional man-years' effort. Of this total, 1.8 is specifically directed to weed control in oilseeds and peanuts at Stoneville, Mississippi; Tifton, Georgia; and Beltsville, Maryland.

The Department has a long-term continuing program of basic and applied research on various phases of nematology which contribute information of value to nematode control. In the past few years, as State nematology programs have developed, there has been increased emphasis on basic research by the Department. Basic research on nematode taxonomy and physiology is located in Beltsville, Maryland, while ten field stations combine applied and basic research in varying proportions. Research on nematodes affecting oilseeds and peanuts is conducted at Tempe, Arizona; Auburn, Alabama; Tifton, Georgia; Beltsville, Maryland; and Jackson, Tennessee.

The Federal scientific effort devoted to research in this area in FY 1964 totaled 19.0 man-years. Of this, 7.0 were devoted to basic research on nematodes and 1.3 to oilseeds and peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

State experiment stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical plants and soils.

Nematode investigations are being conducted at most State Stations and many of these scientists participate in the Regional Research Projects concerned with phytonematology. Through these and other projects at the various institutions, scientists are contributing new knowledge on the genetics, physiology, and pathology of nemas. Some station scientists as a result of their recent findings on nemas as vectors of viruses, are conducting intensive investigations of the biologies of this process. Other research on fundamental problems in nematology as well as work on identification and control are indicated in the appropriate crop section of this report.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

I. Weed Control

A. Soybeans. Linuron gave excellent preemergence weed control in soybeans without crop injury in Mississippi. As a directed postemergence spray at the second trifoliar-leaf stage of soybeans it gave excellent weed control without injury to the crop. Prometryne in broadcast sprays killed 90% of the soybeans. In Georgia, several mixtures and rates of amiben, DNBP, NPA, PCP and swep provided control of annual weeds throughout a season of adverse weather. Only PCP applied alone at higher rates provided equivalent weed control with no decrease in soybean tolerance.

B. Peanuts. In Georgia, subsurface sprays of EPTC applied with a newly designed subsurface applicator were several times more effective for controlling nutsedge in peanuts than disc-incorporated or preemergence sprays. For the second consecutive year, a mixture of DMPA and DNBP applied at the ground-cracking stage increased peanut yields. Organoleptic comparisons showed that peanuts from DMPA-DNBP treatments did not differ significantly in sensory characteristics from those treated with standard recommended mixtures. Preemergence application of 2,4-DEP and DNBP mixture provided excellent weed control in peanuts in Mississippi.

C. Other Oilseed and Industrial Crops. In Arizona, annual weeds in safflower were controlled by preplant applications of CIPC, IPC, and EPTC. Diuron applied in directed postemergence sprays did not reduce yields of safflower seed. Amiben on castorbeans, CIPC on sesame, and amiben, NPA, DCPA, or linuron were satisfactory preemergence herbicides for weed control in field peas in Mississippi.

II. Nematode Control

A. Oilseeds and Peanuts. In several field experiments in Tennessee, comparisons were made of the effect of rotations with cotton and the resistant soybean varieties Peking and NC-55 on soybean cyst nematode populations. In all cases the effect was much the same, nematode populations decreasing so much that no larvae could be found in the soil. But even after 4 years of resistant crops, high nematode populations built up rapidly when susceptible soybeans were again planted.

Irradiation of soybean seed apparently produced a few mutations which are being tested for resistance to soybean cyst nematode. In tests designed to detect "strains" or "races" of the soybean cyst nematode, no clear differences in ability to reproduce have been demonstrated between populations from various locations in the country. The only difference in plant symptoms was marked yellowing of soybean plants infected by a population of nematodes from Pender County, North Carolina, as compared with populations from other parts of the country.

Soybean cyst nematodes did not increase during the fall and winter on hairy vetch, common vetch or the weed, henbit deadnettle, growing in plots in Tennessee. On plants grown during the summer, the increase in nematode populations was high on soybeans, Rowan lespedeza, and the weed Sesbania macrocarpa (often called wild coffee bean). On Kobe lespedeza, and Azuki bean the increase was moderate. On mung bean, snap bean, and Lespedeza sericia, it was low.

PUBLICATIONS - USDA and COOPERATIVE PROGRAMS

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SOYBEAN AND PEANUT INSECTS
Entomology Research Division, ARS

Problem: Soybeans and peanuts are severely damaged by several insect pests in the different areas where these crops are grown in the United States. The increasing concentration of acreage in soybeans and possibly the adaptation of native insects to this crop are resulting in more varied and more serious insect problems. In the absence of specific support for research on soybean insects, some shifts in emphasis have been made to investigate some of the problems. However, basic information is lacking on the biology of many of these pests and on the extent and nature of damage they cause to these crops. Such information is needed to serve as a foundation for the development of satisfactory control methods. Some insecticides, although highly effective in controlling insects on soybeans and peanuts, cannot be used because they leave harmful residues. Further, certain insects have developed resistance to insecticides that are currently recommended. For the immediate future, there should be continued effort to find insecticides that can be used safely and that give effective, economical control of all species of insects attacking these crops. For more desirable long-range solutions to the problems, more attention needs to be given to nonchemical control methods, with particular emphasis on insect-resistant crop varieties and biological control agents and the exploration of new chemical approaches such as attractants and repellents.

USDA AND COOPERATIVE PROGRAMS

The Department has a limited program involving basic and applied research on the insect problems of peanuts and soybeans directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists and chemists. Studies on soybean insects are conducted at Columbia, Mo., and on soybean and peanut insects at Tifton, Ga., in cooperation with the Missouri and Georgia Experiment Stations.

The Federal scientific effort devoted to research in this area totals 1.5 professional man-years. Of this number 0.3 man-year is devoted to basic biology; 0.3 to insecticidal control; 0.5 to insecticidal residue determinations; and 0.1 to biological control; 0.1 to varietal evaluation for insect resistance; 0.1 to insect vectors of diseases and 0.1 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The States have an active program of research on soybean and peanut insects.

On soybeans, research is in progress to determine the amount and type of injury caused by various species of insects. Life histories and habits are studied under varied temperature and humidity conditions in the laboratory. Periodic field surveys are conducted to determine variations in seasonal

population levels of insects on soybeans and other host plants. Control treatments are applied at different times through the season to establish population levels necessary to cause significant damage.

Peanut insect research is concerned with seasonal history and habits of insect pests, determining economic infestation levels, chemical and cultural control and plant resistance studies. Biological information is being obtained as a basis for developing control programs. Rearing methods have been worked out for the most damaging species. Pests which appear sporadically are being studied to determine the factors responsible for outbreaks and the extent of injury they cause. Chemical controls and effects of tillage, irrigation and other management practices are evaluated under field conditions. The appearance of resistance in the southern corn rootworm to commonly used insecticides has necessitated intensification of nonchemical control research. Extensive comparisons of peanut introduction lines are being made and plants which exhibit resistance to insects are selected for further study and possible use in breeding programs.

There are 3.4 man-years devoted to soybean and peanut insect research in the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Soybean Insects. Broad-headed bugs, Coriscus eurinus and C. pilosulus, infested several fields of soybeans at Columbia, Mo., and fed extensively on the pods in the latter part of the 1963 season. Complete cycle from egg to egg required about 50 days. These bugs overwinter as eggs which are laid on the ground in the fall. Adults of both species were found from June 10 to mid-November.

The larvae of the sciarid fly, Sciarus sp., fed extensively on the roots of soybeans in the laboratory. The life cycle required approximately 20 days. This insect is a potential pest of soybeans, particularly in the spring in locations where the soil is moist.

At Tifton, Ga., the mean life cycle of the lesser cornstalk borer associated with soybeans and cowpeas was 43.1 days. Eggs hatched after 3 days incubation, larvae pupated in 19.6 days, pupation averaged 10.2 days, and mated female moths live 10.3 days. Unmated moths, both male and female, lived an average of 22.3 days. Adults are most active in the field on warm still nights when temperatures are above 80° F. Copulation and oviposition take place in darkness. Females deposited an average of 125.7 eggs each. Laboratory-confined moths failed to copulate when temperatures were 70° F. or below.

2. Peanut Insects. Cooperative investigations in 1963 with the Crops Research Division at Tifton, Ga., were made on the effect of insect pollinators in natural crossing in breeding nurseries in relation to producing pure peanut seed stock. When flowering peanut plants were caged to exclude solitary bees, outcrossings did not occur.

B. Insecticidal Control

1. Lesser Cornstalk Borer. Ten insecticides that have shown effective control of the lesser cornstalk borer attacking seedling soybeans and cowpeas were retested in 1963. All were applied in granular form at 2 lb. per acre in an 8-inch band over rows of seedling cowpeas in the two-leaf stage. All gave good control. Listed in the order of effectiveness were trichlorfon, AC 43064, ethion, diazinon, endrin, endosulfan, fenthion, carbophenothion, phorate, and Di-Syston.

C. Biological Control

One new parasite species, Chelonus (Microchelonus) n. sp. was collected at Tifton, Ga., in 1963. It contributed significantly to total insect parasite activity on the lesser cornstalk borer. Total parasitism by several species of insect parasites exceeded 50% in a number of samples of field populations. Parasite species collected to date in Georgia include Telenomus (Telenomus) n. sp., Chelonus (Microchelonus) n. sp., Pristomerus pacificus melleus, Orgilus n. sp., Stomatomyia floridensis, Bracon mellitor, and Plagiprospherysa parvipalpis.

D. Varietal Evaluation for Insect Resistance

1. Soybean Insects. At Columbia, Mo., over 100 plant introductions and experimental varieties of soybeans were evaluated in a field cage 12'x6'x60' for damage by the green stink bug, Acrosternum hilare. Density of bugs in the cage was one per square foot. Damage by the bugs in general was heavier for the later maturing soybean varieties. However, several varieties within each maturity group were damaged significantly less than the mean of that group.

E. Insect Vectors of Diseases

1. Soybean Yeast Spot. Field and laboratory tests at Columbia, Mo., with several species of Pentatomidae clearly indicated that Euschistus servus, Thyanta custator, Euschistus tristigmus can transmit yeast spot disease of soybeans in the field. Previously, Acrosternum hilare had been determined to be a vector. No evidence was found to involve Cosmopepla bimaculata and Peribolas lumbularius in the transmission of the disease. Data on E. variolarius and E. euschistoides are still incomplete.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

Hammons, Ray O., Krombein, K. V., and Leuck, D. B. 1963. Some bees (Apoidea) associated with peanut flowering. Jour. Econ. Ent. 56:905.

PEST CONTROL TECHNIQUES AND EQUIPMENT; HARVESTING, AND HANDLING OPERATIONS; AND CROP PREPARATION AND FARM PROCESSING

Agricultural Engineering Research Division, ARS

Problem. Many pests attack oilseeds and peanuts resulting in dollar losses to farmers each year. Plant diseases, weeds, insects and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. In many situations, effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended. Thus, equipment to control a wide variety of pests on a wide variety of crops is required. There is a need for improved methods of much greater efficiency for applying pesticides to plants and the soil.

Development of equipment and methods for efficiently harvesting and farm handling oilseeds and peanuts, with emphasis on the preservation of inherent qualities during these processes is needed. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of some crops, much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled.

Development of better methods, techniques, and equipment for use on farms for the initial preparation for market or the processing of oilseeds and peanuts is needed to increase efficiency in the use of labor and equipment, preserve quality and prevent spoilage and damage from mechanical handling. While considerable information has already been obtained for the development of processes such as drying and separation, basic and more precise information must be developed for these and other processes before development progress can be continued. The underlying principles that pertain to the cleaning and drying of different crops, curing of peanuts, and sorting need to be determined. The methods for processing farm crops are largely dependent on production practices and dictated by future handling or storage requirements. Consequently, this requires interdisciplinary collaboration in the creating of a completely mechanized program of crop production.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers' problems. Pest control research on soybeans is conducted at Columbia, Missouri, and Ames, Iowa. The Federal scientific effort devoted to research in this area totals 0.6 on soybeans.

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on oilseeds and peanut harvesting equipment and methods is cooperative with the Experiment Stations at Stillwater, Oklahoma (castor beans); Bogulsa, Louisiana (tung nut); and Holland, Virginia (peanuts). The Federal engineering effort devoted to research on oilseeds and peanuts harvesting and handling operations and equipment totals 3.6 professional man-years.

The Department's effort in the area of crop preparation and farm processing (except cotton) constitutes a long-term program involving agricultural engineers and statisticians engaged in both basic and applied research on the engineering phases of crop preparation and farm processing. Research on the processing of tung nuts is conducted at Bogalusa, Louisiana, in cooperation with the Experiment Station and industry. Drying of castor seed is cooperative with the Oklahoma Experiment Station. The Federal engineering effort devoted to research in this area totals 0.4 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Both basic and applied research investigations which have been designed to discover and develop methods, techniques, and equipment for control of pests that attack oilseed and peanut crops are in progress at a number of Agricultural Experiment Stations.

Many of the state agricultural experiment stations are engaged in some aspect of basic or applied research which is concerned with improving machines and methods for efficient harvesting and farm handling of oilseed and peanut crops. Much of this research effort is cooperative with the Department.

The state agricultural experiment stations are involved in both basic and applied research studies which have as their broad objectives the development of improved methods, equipment and techniques for preparation and processing of oilseed and peanut crops to preserve quality and prevent spoiling while in storage.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Pest Control Techniques and Equipment

Weed Control in Corn and Soybeans.

1. In investigations cooperative with the Iowa Station, overall spray applications of Atrazine and Simazine on fall plowed, spring plowed, and unplowed ground controlled weeds in corn throughout the season. When 2,4-D was used, 2 cultivations were required for adequate control. Residues accumulated after 4 years of continuous corn reduced the effectiveness of all herbicides. With the exceptions of Atrazine and Simazine, granular herbicide formulations controlled weeds as well as or better than liquids when used at planting time. One additional cultivation was required with band applications as compared to overall applications of pre-emergence herbicides. Soil incorporation with row-wheels, rotary hoes, drag harrows, and dragging hoes did not improve the effectiveness of liquid or granular formulations of pre-emergence herbicides.

Essentially weed-free conditions throughout the year were obtained on 7, 14, 20, and 21-in. corn rows in Iowa with an overall application of Atrazine spray at planting time. However, some weed recovery did take place on 28- and 40-in. rows. With a rotary hoe operating at a 2-in. depth, excellent weed control was obtained on continuous corn on ridges. Ground corn as a carrier for 2,4-D in granular formulations demonstrated the same effect as clay when used in Iowa at various rates at planting time. Atrazine granular sizes of 20/25, 25/30, and 40/50 showed no difference in effectiveness when applied at planting time.

Seven-in. band applications of pre-emergence herbicides were as effective in Iowa as 14-in. bands for weed control in soybeans. The dragging rotary hoe was quite effective for weed control in beans as compared to the conventional rotary hoe but caused greater stand reduction. Using disk hillers for cultivating soybeans improved weed control as compared to the use of conventional sweeps.

Final field studies were made in Missouri to determine the effect of row spacing on Clark soybeans with and without pre-emergence treatments of Amiben at a rate of 3 lbs. per acre. Mechanical cultivations with the rotary hoe and sweep cultivator were also included in this study. Rotary hoeing in the 8- and 16-in. row spaces did not appreciably reduce the weed yields or increase the soybean yields when used alone, but when Amiben was used, rotary hoeing did not appreciably affect weed yields but significantly increased soybean yields. Amiben controlled weeds more effectively in narrow-spaced soybeans than in the wide-spaced soybeans. Sweep cultivations of 24, 32, and 40-in. rows decreased weed yields and increased soybean yields.

Field studies were initiated this year in Missouri to determine the effectiveness of 8, 10, 12, 14 and 16-in. band applications of 2,4-D (2 lbs. per acre), Simazine (2 lbs. per acre) and Atrazine (2 lbs. per acre) for weed control in corn. Narrow band applications of all herbicides were just as effective as wide bands for weed control. Eight and 10-in. bands were more difficult to cultivate than the wider bands. Band applications of Simazine and Atrazine treatments resulted in higher corn yields than 2,4-D. Considerable reduction in application cost could result by using narrow bands.

Field studies were initiated this year in Missouri to determine the effectiveness of 8, 10, 12, 14 and 16-in. band applications of Amiben and NaPCP for weed control in soybeans. More weeds, but increased soybeans yields, were found in plots where Amiben was applied in narrow bands. Weed control and soybean yields were just as good in plots receiving narrow band applications of NaPCP as they were in plots receiving wide band applications. Weeds were controlled over a band wider than the applied band after rainfall occurred.

2. Initial field studies were made to compare the effectiveness of four methods of incorporating three pre-emergence herbicides for weed control in corn. Trifluralin, Atrazine, and 2,4-D butyl ester were applied at 2 lbs. per acre and EPTC was applied at 3 lbs. per acre. All herbicides were applied after planting and incorporated with a drag harrow, tandem disk, rotary hoe, Gandy Ro-Wheel with spray nozzle in front, and Gandy Ro-Wheel with spray nozzle in back. Incorporating with the disk resulted in better weed control but more corn damage. The rotary hoe and drag harrow resulted in fair weed control and least damage to the corn. The Gandy Ro-Wheel was as effective when the herbicides were applied ahead of the wheel as they were when applied behind the wheel, and overall it was about as effective as the disk harrow or rotary hoe. All incorporation resulted in increased weed control with the herbicides used.

Final field studies were made to determine the effect of rainfall (by irrigation) or soil moisture on weed control with granular and liquid formulations of 2,4-D ester. The addition of moisture increased weed control with granular formulations more than it did with liquid formulations of 2,4-D. Some corn damage and stand reduction were noted when water was applied to treatments of liquid formulations of 2 lbs. per acre of 2,4-D. The results of four years research indicate that there is a possibility of reducing the amount of herbicide used if moisture is made available to the herbicide after application.

Field studies were initiated to compare the effectiveness of 10 and 6.6 percent concentrations of granular Amiben (3 lbs. per acre) for weed control in soybeans. Increasing the total amount of granules while applying the same acid equivalent did not result in increased weed control

or soybean yields. The liquid formulation of Amiben was just as effective as the granular formulation. Studies will be continued with additional investigations of herbicidal movement in soil.

Laboratory studies were conducted to determine the effects of herbicide concentrations and mixing temperature on the relative viscosity of oil-in-water and water-in-oil (invert) emulsions of 2,4,5-T. The relative viscosity of water-in-oil emulsions (water as base) measured with the Stormer viscosimeter was affected more by mixing temperature than it was by concentration of water when mixed within ranges suggested by the manufacturer. The effect of the same variations were not so easily described when using oil-in-water emulsions.

Laboratory studies were conducted to determine some of the metering characteristics of several granular herbicide carriers. The effect of carrier type, granule size distribution, granule moisture content, flow rate and agitator speed were determined when granules were metered with the Gandy and Noble applicators. Increased variation in rate of change in flow rate per change in agitator speed resulted with large flow rates for the Gandy applicator. This change in flow rate variation was larger and more erratic for the Noble applicator than it was for the Gandy applicator. Additional moisture did not change the flow rate characteristics when measured on a weight basis.

B. Oilseeds and peanut harvesting equipment

1. Castor combine for harvesting damp or dry castor beans. Castor beans are left in the field the full growing season to obtain optimum yields. As a result the crop is normally the last to be harvested in the fall and comes at a time of frequent adverse weather conditions--high humidity, fog and wet weather. Since the presently used castor harvesters can be used only when the seed capsules are completely dry, favorable harvesting conditions are limited. Development of a harvester which will harvest castor beans when damp or dry would lengthen the harvest time and permit more acres to be harvested per machine. Research started last year was continued this year. An attachment was developed to harvest closely spaced rows which included 8 rows in place of the usual 4 rows spaced 40-inches apart. In order to facilitate using large wheels on tractors, the rows were paired two 14-inch rows with a spacing of 26 inches between pairs. This study was started to determine the practicability of harvesting close row spaced plants, should increased economical yields materialize from close row plantings. With this pattern of spacing, the combine was maneuvered satisfactorily on four different varieties without seed being knocked off adjoining rows by the harvester.

Development of moving brush row seals. A new principle of conveying loose castor seed into the combine header using moving row brush seals was designed and constructed as an attachment on a regular combine header. The principle proved to be effective and should cost less to incorporate in a machine than attachments now used on commercial machines. A patent application has been filed on the moving-brush principle.

Conditioning castor beans for harvest by chemical defoliation. Castor beans during a late growing season have been conditioned for harvest, with varying degrees of success, by using chemical sprays to dry the seed capsules and defoliate the leaves. The variation in castor bean varieties, as well as weather and crop conditions have shown varying results in effectiveness and requirements of chemical spray material. A varietal trial of castor beans which included 49 hybrids and varieties was successfully defoliated using a chemical "Diquat" with water. The material could not be fully evaluated because wet weather set in and prevented harvesting.

2. Development of tung harvester. The major cost of tung production is in harvesting the crop by the common practice of using hand labor. Dependable labor is becoming scarce and more costly each successive year. Substitution of hand labor with efficient and effective machines could reduce harvesting and handling costs and would result in an orderly harvest. One of the biggest problems in developing an effective tung harvester is the wide range of harvesting conditions which vary from extremely dry and dusty to very wet over widely varying soil and terrain. Design factors affecting the harvester efficiency, cleaning ability, and the operation of the handling of tung from the harvester to the processing plant were studied. More effective conveying equipment was installed on the machine and many parts were simplified. The use of air for disposal of excessive bulk of leaves showed promising results. Further development is needed to make the machine more effective under a wide range of crop, soil and weather conditions.

3. Pruning of tung trees to facilitate the use of equipment in production and harvesting. Tung trees normally produce limbs low to the ground that will prevent the use of machines in production and harvesting without extensive damage to the trees. A study was started to determine the productivity of established trees to pruning of the lower limbs which would permit the effective use of machinery. This experiment will continue for a number of years to fully evaluate the effect of pruning. A similar experiment was started on seedlings to determine whether this type of pruning early in the life of the trees affects the total life production of tung fruit.

4. Peanut digger development. Limited field tests with the project's 1962 model peanut digger indicated that further improvements are needed to eliminate vine wrapping of the upper conveyor. The relatively short conveyor designed for maximum economy did not elevate the vines adequately for an

effective transfer onto the soil separators. A small quantity of vines passed between the conveyor and elliptical soil separator assemblies, which was due to the tendency of the vines to wrap. The addition of segmented baffles on the upper conveyor shaft to eliminate vine wrapping was ineffective. Additional changes and tests are planned for improving the digger's performance.

5. Specific gravity and grade of green-harvested peanuts. Repeated tests with samples of green-harvested unshelled peanuts have shown that four different quality grades of peanuts were often found to have the same specific gravity. This characteristic was noted in at least one-third of the different specific gravity categories studied. These data show that separation of immature peanuts from mature peanuts by pneumatic systems of the vacuum or pressure type, or with liquids of varying densities, are not likely to become satisfactory.

Size and grade relationship of green-harvested peanuts. In a study of the diameter-grade relationship of a sample of green-harvested peanuts 46 to 56 percent of the total number of immatures were approximately one-half inch or smaller in diameter. These may be separated by screening with a minimum loss of good quality unshelled peanuts. Remaining immatures and all other peanuts of economic value in the sample were larger than one-half inch in diameter. In an evaluation of a separation procedure based on length-grade relationship, 25 to 31 percent of the immatures may be removed without a loss of good quality peanuts. Mechanical separation according to diameter may be expected to remove an estimated 50 percent of the immatures. In a combination procedure based on mechanical separation according to both diameter and length, incorporation of the length factor would not increase separation efficiency more than 4 to 5 percent.

Mechanical screening of green-harvested peanuts. Mechanical screening studies were conducted to separate immatures and foreign material from green-harvested peanuts using slotted perforations 5/16-, 3/8-, 7/16-, 15/32-inch wide x 3 inches long. In the order listed, these screens removed 47, 61, 72 and 85 percent of the total number of immatures and 45, 62, 73 and 74 percent of the foreign material by weight. The loss of unshelled peanuts through the 7/16-inch and 15/32-inch screens was estimated to be $0.32 and $1.49 per ton, respectively. Primary objection to screening is the potential loss of the loose shelled kernels.

Numerically, the number of immatures in green-harvested peanuts ranged from 15 to 25 percent, whereas peanuts combined after 6 days in the windrow contained only 2.5 to 4.5 percent immatures. The immatures in green-harvested peanuts after drying to equilibrium moisture content (farmers' stock) represented 1.1 percent of the total sample by weight. Those combined after 6 days in the windrow contained 0.35 percent immatures by weight. Green-harvested peanuts contained approximately 2,680 pounds more moisture per ton of farmers' stock peanuts than peanuts which were dried 6 days in the windrow.

Attempted separation of green-harvested immature peanuts from mature peanuts using sensitive pneumatic and electrostatic separators was not satisfactory as the equipment did not make a clear cut separation of the mature from the immature peanuts. An electronic color sorter designed and used for separating low moisture unshelled Virginia type peanuts also failed to make a satisfactory separation.

C. Crop Preparation and Farm Processing

Tung nut processing

1. Farm processing of tung nuts. Conditioning high moisture tung fruit with or without hull for quality maintenance during storage requires knowledge of the basic factors and parameters affecting release of moisture from tung fruit. Additional data on the relation of static pressure to air flow rate, depth and density of fruit, were obtained. The static pressure requirements were much lower for equivalent air flow rates of tung having the lower moisture content. Additional studies will be made to determine the drying requirements of tung with and without heat. The information already obtained relating static pressure to air flow will be used as a guide for further studies.

Drying castor seed

1. Resistance of hulled and unhulled castor beans to air flow. Castor beans, at times, are harvested with high moisture content not acceptable to the processor. In addition, castor beans stored at high moisture are subject to deterioration and increased acid content of the oil within the seed. Investigations were continued to determine the relationship of air flow to resistance, density, moisture and depth both for hulled and unhulled castor beans. A pilot dryer was remodelled to allow more accurate air flow and resistance measurements than permitted previously. Basic relations of these factors are yet to be analyzed by multiple regression. Exponential equations and correlation coefficients will be determined. Results of these data will be used as guidelines for drying studies of hulled as well as unhulled castor beans.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

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B. Crop Harvesting and Handling Operations and Equipment

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II. NUTRITION, CONSUMER, AND INDUSTRIAL USE RESEARCH

FLAXSEED

INDUSTRIAL UTILIZATION OF LINSEED OIL

Northern Utilization Research and Development Division, ARS

Problem. Traditional markets for linseed oil, the major drying oil produced and used in the United States, are threatened by widespread use of synthetic products derived from nonagricultural sources. Thus, over the years 1950-1960, use of linseed oil in drying oil products decreased from 590 to 351 million pounds because of displacement by synthetic materials capable of better performance. During the same period, consumption of synthetic products in protective coatings increased by 50 percent.

To restore the competitive position of linseed oil, new or expanded markets are urgently needed. Such markets can be achieved by an adequate program of basic and applied research. Recent studies by Department scientists have resulted in commercial manufacture and sale of linseed emulsion paints for exterior use that are competitive with synthetic resin emulsion paints. Use of these new linseed oil paints is expected to expand and assist in maintaining linseed oil in the market for exterior paints, which amounted to 70-75 million gallons in 1962. Another new product from linseed oil to which Department research is contributing is a protective coating for concrete that prevents deterioration from deicers and freezing and thawing in winter. Indications are that use of these two new products has halted the decline in consumption of linseed oil. However, additional research is needed to insure maximum acceptance and consumption of these new coatings and to provide still other new or improved products from linseed oil that can maintain and increase its use in all types of protective coatings, a market amounting to 700 million gallons in 1963.

Other new outlets can be realized by chemical modification of linseed oil to obtain materials that will find applications in the multibillion-pound annual market for products of the organic chemical industry. To furnish a sound basis for chemical modification, a broad program of basic research on linseed oil is required to furnish new leads and new concepts that will point the way to those products having the best chance for acceptance.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic research and on the chemical reactions of linseed oil and its component fatty acids and in the application of the knowledge gained to the development of new or improved products for the chemical and protective coating industries.

The Federal scientific effort concerned with research on industrial uses for linseed oil total 18.2 professional man-years. Of this number 4.8 is devoted to industrial chemical products and 13.4 to protective coating products.

The current program at Peoria, Illinois, does not include research specifically devoted to chemical composition and physical properties.

Research at Peoria, Illinois, on industrial chemical products (4.8 professional man-years) involves exploratory studies to find new reactions and chemical derivatives and basic and applied research on cyclic fatty acids.

Studies on protective coating products in progress at Peoria, Illinois, (10.4 professional man-years) include investigations on new polymers from linseed oil for use as water-soluble vehicles for coatings and basic and applied research on problems related to development of linseed emulsion paints. Research contracts on protective coating products (3.0 professional man-years) are in effect with Kansas State University, Manhattan, Kansas, for research on the use of linseed oil to protect concrete (.7 professional man-year) and on its use as a single coating for both curing and protection of concrete (.9 professional man-year); with North Dakota State University of Agriculture and Applied Science, Fargo, North Dakota, for investigations of aldehyde oils as components of protective coatings (.4 professional man-year); and with Stanford Research Institute, Menlo Park, California, for studies on properties and reactions of new vinyl copolymers of linseed oil (1.0 professional man-year). Basic investigations on the physical chemistry of linseed emulsion systems were completed during the reporting period by the University of Southern California, Los Angeles, California.

The Department also sponsors research conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves a grant to the Experiment Station for Fats and Oils, Milan, Italy, for studies on minor constituents of linseed oil (5 years, 1960-1965). Research on industrial chemical products is conducted by this institution also under a grant for the investigation of products obtained by thermal polymerization of linseed and other polyunsaturated vegetable oils (4 years, 1960-1964) and by the Regional Research Laboratory, Hyderabad, India, under a grant for exploratory studies on hydroxylation of linseed and safflower oils (5 years, 1963-1968). Research on protective coating products involves a grant to the Paint Research Station, Teddington, England, for fundamental research on organometallic compounds as components of protective coatings (5 years, 1960-1965).

PROGRAM OF STATE EXPERIMENT STATIONS

State stations did not report research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Minor constituents of linseed oil. At the Experiment Station for Fats and Oils, Milan, Italy, research continued on the identification of minor constituents of linseed oils. A triterpenic alcohol originally isolated

from olive oil has been identified as 24-methylene-cycloarthanol. It is found in at least 13 other oils including linseed and soybean oils. The Fitelson-positive compound in linseed oil is a triterpene alcohol of the euphane series but different from any known member of this series. Work has been started on the effect of minor constituents on the spreading and wetting properties of six American and one Italian linseed oils. Interfacial tension measurements on these oils varied from 5.3 to 20.5 dynes/cm. but surface tension values were essentially constant. This work is being conducted under a PL 480 grant.

B. Industrial Chemical Products

1. Cyclic acids. A variety of esters of C_{18} saturated cyclic acid were examined to evaluate their possible potential as synthetic lubricants. Viscosity indexes ranged from 26 to 143 and pour points from -30 to -95° F. Oxidative stability of straight and branched-chain alkyl esters equaled or exceeded that of bis 2-ethylhexyl sebacate. In earlier studies the 2-ethylhexyl ester of saturated cyclic acids showed poor oxidative stability. This result was caused by unrecognized contamination with aromatized cyclic acid ester, since a pure preparation of the latter exhibited much lower oxidative stability than the sebacic acid ester. The saturated cyclic acid used in the present tests contained no aromatic material.

Studies of C_{18} and C_{20} saturated cyclic alcohols in a variety of cosmetic emulsion systems showed that they imparted better feel and esthetic appearance than did cetyl or stearyl alcohols. In antiperspirant formulations containing aluminum salts, the cyclic acids imparted much greater emolliency and reduced tackiness, a persistent problem with such formulations.

Optimum conditions developed in engineering studies on hydrogenation of cyclic acid gave a product containing only 1.1 percent of aromatic product. This level is expected to be satisfactory for most potential uses and to have no significantly adverse effect on oxidative stability of derivatives. Reused hydrogenation catalyst yields less aromatic byproduct than fresh catalyst, a result suggesting the feasibility of a continuous hydrogenation process that would produce little or no aromatic. Purification by a combination of low-temperature crystallization and urea adduct formation appeared to be more practical than either method alone. The limit of effectiveness of liquid-liquid extraction as a means of isolating cyclic acids was apparently reached in current studies with production of a fraction containing 80 percent cyclic acids.

Industrial potential for use of cyclic acids in synthetic lubricants and cyclic alcohols in cosmetics appears to be excellent. Since the cosmetics market can consume premium-priced materials, it could, by absorbing the initial costs of initiating production, assist greatly in establishing saturated cyclic acids as an industrial chemical.

2. Glyceride polymers. At the Experiment Station for Fats and Oils, Milan, Italy, under a PL 480 grant, work has been concerned primarily with structure studies on the dimeric and trimeric acids or esters from heat polymerized oils. Dimer acids have been ozonized and attempts are being made to characterize suitable derivatives of the cleavage products, e.g., aldehyde-acids and their dinitrophenylhydrazones, diacids, etc., by several chromatographic techniques. Information available to date is insufficient to elucidate the structure of the polymeric acids but a number of cleavage product derivatives have been tentatively identified, e.g., butyric acid, dibasic acids from C_4 to C_{11} ($C_9 > C_4 > C_8 > C_{10} > C_{11} > C_5 > C_6 > C_7$) and a non-linear aldehyde containing more than 15 carbon atoms.

3. Hydrogenation of linseed and safflower oils. Research has been initiated under a PL 480 grant to the Regional Research Laboratory, Hyderabad, India. A literature survey was completed, and experimental work has been initiated. However, no significant results have yet been achieved.

C. Protective Coating Products

1. Emulsion paints. Coulter counter data on particle size of 135 emulsion samples were processed by a digital computer. Variables involved included oil viscosity, temperature during preparation, rate and duration of shear and age of emulsion. Results showed that mean particle size decreased with decreasing oil viscosity. Increased mixing time did not alter particle size significantly but the size distribution did become narrower. An additional relationship revealed by the computer is that regardless of viscosity and temperature, oil particle size approaches a limiting value, which may, however, be dependent on type and concentration of the emulsion system and on the rate of shear.

This latter finding represents an important new approach--optimization of the emulsifier system in terms of composition and concentration--to control of the rheological properties of linseed oil emulsions and paints made from them. Studies on pigment interaction showed that aggregation of two pigments will occur at pH values between the isoelectric points of these pigments. This happens because within this range particles of the two pigments will have opposite charges. The results of this fundamental research provide the basis for a practical method for predicting interaction between any two pigments and the conditions under which such interactions would be expected. Commercial interest in linseed emulsion paints continues to increase. Recently a major paint manufacturer of national importance announced test marketing of a linseed emulsion paint. Although a large number of companies have put such paints on the market, these have been the smaller regional paint manufacturers. In a related development, an industrial company has prepared reactive linseed emulsifiers in its pilot plant. These emulsifiers were first prepared at the Northern Division early in its research on linseed emulsion paints.

2. Linseed coatings for concrete. Further study at Kansas State University of the use of linseed oil emulsions in curing fresh concrete showed that ASTM specification C156-55T was met and that at 0.16 lb. of linseed oil per square yard, performance exceeded two commercial products tested.

Preliminary results of tests on use of linseed oil as an antispalling agent to protect air-entrained concrete revealed that uncoated beams made with Florence limestone showed general surface deterioration after 22 freeze-thaw cycles. Beams coated with linseed oil showed very slight surface flaking after 77 cycles. At the end of 22 cycles the uncoated beams were coated with linseed oil, and no further deterioration was observed after 55 additional cycles.

These data on protection of air-entrained concrete with linseed oil coatings are confirming the empirical beliefs regarding the value of this treatment that have already resulted in considerable use of linseed antispalling products. Positive evidence of the value of linseed oil coatings obtained by impartial investigators under scientifically controlled conditions should eliminate skepticism and provide the key to their general acceptance and use on air-entrained concrete. Demonstration that such coatings can stop further deterioration of concrete already damaged by freeze-thaw would justify their use on old highways and other concrete work as well as on new, thus vastly increasing the potential consumption of linseed oil in this application.

3. Water-soluble and other new vehicles based on linseed oil. Research on new polymers and vehicles continued to supply leads to promising products justifying further study and evaluation in protective coatings. In synthesis of various linseed acyl methyl glycosides needed for investigation as water-soluble vehicles, a new blocking group, the methoxy carbonyl group, was discovered. This synthetic method may prove generally useful in organic chemistry. Attempts to prepare the vinyl ether of hydroxy ethyl linseed amide have so far given low yields. Vinyl esters of soybean fatty acids were successfully epoxidized with concentrated hydrogen peroxide and formic acid. The dihydroxyethylamide of unsaturated fatty acids was prepared in yields exceeding 90 percent by sodium-catalyzed aminolysis of linseed oil. Esterification of the product with various dibasic acids yielded resinous polymers showing promise as coating films. Set-to-touch times ranged from 0.75 hour (terephthalic acid ester) to 5 days (dimer acid ester). By reacting an equimolar mixture of tris hydroxymethyl aminomethane and linseed fatty acids, a new oxazolinediol was obtained. This product may be useful as a component of alkyd resins.

Initial results of contract research at North Dakota State University on utilization of aldehyde oils in coatings showed that linseed monoaldehyde oil may give baked and fast air drying films with boron trifluoride catalyst. The crude mixed aldehydes obtained by reductive ozonolysis of soybean methyl esters were reacted with tris hydroxymethyl aminomethane

and then linseed fatty acids to yield drying oils having drying properties inferior to those of similar products prepared with formaldehyde.

4. Organometallic compounds in paints. New vehicles comprising gallate-, tannate-, or pyrogallol-modified vegetable oils, esters and oil-modified alkyd resins have been developed. These vehicles, when applied to unoxidized iron and steel surfaces from solutions in or containing monoethers of ethylene glycol, were found to complex with the metal surface and produce durable, anticorrosive coatings. Further studies on adsorptive properties of titanium dioxide pigment revealed that phosphorylated methyl oleate was a superior stabilizing agent for dispersions of rutile in organic paint solvents. Applications for public service patents have been filed on both of these developments as well as on the novel acetoacetate-type vehicles described in last year's report. This research is being conducted under a PL 480 grant by the Paint Research Station, Teddington, England.

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*Research supported by PL 480 funds.

SOYBEANS
FOOD AND INDUSTRIAL USES FOR SOYBEAN OIL
Northern Utilization Research and Development Division, ARS

Problem. Soybean oil is now the major edible oil of the United States and the most important source of nutritionally important linoleic acid. However, this oil contains an unstable component (linolenic acid) that limits its use as a liquid oil both domestically and in foreign markets. It is estimated that in 1963 at least 3.8 billion pounds of soybean oil (about 90 percent of total domestic use) was consumed in edible products, of which about two-thirds was consumed in hydrogenated form as margarine and shortening. However, production of soybeans continues to increase rapidly and exceeded 700 million bushels in 1963.

The most promising outlets for oil from this ever-growing production of soybeans appear to be in foreign markets as edible oils and fats and in domestic industrial uses. The potential market for vegetable oils imported by Europe is estimated at over 7 billion pounds by 1966. For soybean oil to capture a growing share of this market, more information is needed to show how to eliminate unstable linolenic acid without loss of nutritive value, to determine the extent to which minor constituents influence flavor and other properties of the oil, and to discover methods for modifying hydrogenated soybean oil to achieve desired functional properties such as melting point and texture. This information would also serve as the basis for improving soybean oil for domestic use both as a liquid oil and in its hydrogenated forms. Some additional consumption in the United States might be anticipated because of extended utility resulting from these improvements, even though consumption of edible fats and oils mainly increases with population growth. To achieve the objective, a broad program of basic and applied research is required to provide more knowledge of the properties of linolenic acid and of minor constituents of soybean oil; of the changes that take place in these and other components during oxidation, hydrogenation, and heating; of the effects of these changes on flavor, nutritive value, stability, and other qualities of the oil; and of the effects of modification of glyceride structure on functional properties of hydrogenated forms of soybean oil.

As an industrial oil, soybean, like linseed oil, is faced with growing competition from synthetic products derived from nonagricultural sources. As an industrial source of linoleic acid, soybean fatty acids must also compete with tall oil fatty acids, a byproduct of paper manufacture. The best opportunity for increasing industrial applications of soybean oil appears, therefore, to be development of products that retain the glyceride structure of the oil. Thus, aldehyde oils, a recent discovery of Department scientists, appear to have a promising future, if current research and development is successful, in the multibillion-pound market for resins, fibers, coatings, plastics, plasticizers, pesticides, and paper and textile chemicals. To achieve the potential industrial value of aldehyde oils and

other soybean glyceride products, more fundamental information is needed on reactions of soybean oil that will preserve the glyceride structure and on the physical and chemical properties of the products. Upon this basis, development of a wide variety of new, industrially useful products should be possible.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic and applied research on edible and industrial uses of soybean oil. A food technologist is also required by the program in connection with organoleptic evaluation of edible oils. Objectives of research on edible soybean oil are to identify undesirable flavor components of the oil, to develop basic information on the chemical changes and mechanisms involved in formation or suppression of these components and to apply the knowledge gained to the development of edible soybean oil having improved oxidative, thermal and organoleptic stability. Objectives of research on industrial utilization are to obtain new information on reactions of soybean oil and its components and to use this information to develop new or improved products for use by the chemical and other industries.

The Federal scientific effort for research on soybean oil totals 33.1 professional man-years. Of this number 9.0 are devoted to chemical composition and physical properties, 12.4 to edible utilization, and 11.7 to industrial utilization.

Research at Peoria, Illinois, on chemical composition and physical properties (9.0 professional man-years) is concerned with isolation and identification of components affecting flavor, heat, light, and storage stability of soybean oil and its hydrogenated products and with development of new and improved methods of separation and analysis for use in these studies.

Research at Peoria, Illinois, on edible utilization of soybean oil (9.5 professional man-years) involves basic and applied studies on selective hydrogenation and on interesterification followed by selective extraction as means of stabilizing soybean oil by removal of linolenate. Research contracts (2.9 professional man-years) are in effect at IIT Research Institute (formerly called Armour Research Foundation), Chicago, Illinois, for development of heterogeneous selective hydrogenation catalysts (1.4 professional man-years); at Rutgers, The State University, New Brunswick, New Jersey, for basic studies on heterogeneous catalysts (1.0 professional man-year); and at the University of Illinois, Urbana, Illinois, for basic research on homogeneous catalysts (.5 professional man-year).

Research at Peoria, Illinois, on industrial utilization of soybean oil (10.0 professional man-years) involves exploratory studies to find new reactions and products and basic and applied investigations of aldehyde oils and other aldehydic products. A research contract (1.7 professional man-years) is in

effect with Fabric Research Laboratories, Dedham, Massachusetts, for investigations on poly(ester-acetals) and poly(amide-acetals) derived from aldehyde oils.

The Department also sponsors research on soybean oil conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the Institute for Fats and Their Derivatives, Seville, Spain, for research on removal of trace metals from soybean oil with ion-exchange resins (5 years, 1960-1965) and to Gdansk Polytechnic, Gdansk, Poland, for studies on soybean sterols and their effect on stability of the oil (4 years, 1961-1965). Research on edible utilization is conducted under grants to the University of Granada, Granada, Spain, for studies on the effect of processing on frying quality of soybean oil (5 years, 1962-1967) and to Tokyo University, Tokyo, Japan, for research on hydrogenation of soybean oil (3 years, 1962-1965). Research on industrial utilization involves grants to the University of Helsinki, Helsinki, Finland, for studies on separation of pure fatty acids from mixtures such as soybean fatty acids (5 years, 1960-1965); Queen Mary College, University of London, London, England, for basic studies on alkaline cleavage of polyunsaturated fatty acids (4 years, 1960-1964); and the Experiment Station for Fats and Oils, Milan, Italy, for research on oxidation with atmospheric oxygen to obtain new soybean oil derivatives (4 years, 1960-1964).

PROGRAM OF STATE EXPERIMENT STATIONS

Station research on food and industrial utilization of soybean oil involves study of the chemical, physical, and nutritional properties of the oil. Factors involved in heat damage of oils receive special attention. Biological utilization of fatty acid isomers and the manner of absorption, and biological activities of certain trans fatty acids are being investigated. Research directed to isolation, fractionation and chemical identification of the compounds responsible for the reversion flavor of soybean oil continues. The mechanism involved in flavor reversion of soybean oil and analysis of the noncarbonyls compounds in the isolated reversion flavor are being studied.

Other food product research evaluates the effect of use of vegetable oils in bakery products to be held in freezer storage. Oilseed processing conditions and methods of extraction and recovery of oil from oil-bearing seeds are also under investigation.

The total State effort devoted to soybean oil utilization is about 2.9 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Compositional studies on hydrogenated-winterized soybean oils. Study of the fatty acid composition of liquid and solid (stearine) fractions obtained by acetone fractionation of partially hydrogenated soybean oil showed that the random distribution of linolenic acid in the glycerides prohibited complete removal of this acid from either the stearine or liquid fractions. Linolenic removal depended upon selectivity of hydrogenation. Oleic content of the liquid fractions was relatively constant regardless of the fractionating temperature. Compositional differences were found in linoleic and saturated acids for the liquid and stearine fractions, but trans acids exerted only a minor effect, since they were found in relatively high concentrations in both fractions. Oils hydrogenated to iodine values of 106 and 90 gave crystalline stearine fractions of 2.0 percent and 14 percent at 0° C., 14.8 percent and 34.6 percent at -6° C., and 44.5 percent and 62.3 percent at -16° C., respectively. At these levels of hydrogenation iodine numbers of the solid and liquid fractions differed by 20-25 units.

The stability of soybean oil is markedly improved by the hydrogenation-winterization process because of three important modifications: (1) reduction of total unsaturation, (2) reduction of triunsaturated linolenic acid and (3) removal of residual traces of prooxidant catalyst and catalyst carrier by a microfiltration that occurs when fat particles crystallize out. These suspended trace materials, which are not removable by ordinary filtration, serve as catalysts and centers that promote oxidation.

2. Removal of prooxidant metals. In studies under a PL 480 grant at the Institute for Fats and Oils and Their Derivatives, Seville, Spain, removal of metals from hexane solutions of soybean oil has been greatly enhanced by use of a large-surface, macroreticular ion-exchange resin ("Amberlyst-15"). Iron removed under the best conditions ranged from 2.89 to 3.29 ppm. from oil originally containing 3.34 ppm. Removal of copper and zinc was essentially quantitative. About 0.373 to 0.384 ppm. of manganese was removed from the oil which originally contained 0.516 ppm. A highly significant increase in flavor stability was thereby achieved. The process was most effective with crude soybean oil.

3. Effects of sterols on flavor stability. Experiments at Gdansk Polytechnic, Gdansk, Poland, showed that steroids enhanced autoxidation of soybean oil. However, magnitude of the effect indicated that steroids in the concentrations normally present should not play a significant role in limiting flavor stability. Sterols are chemically modified by the action of bleaching earths, but the products did not catalyze, and might inhibit, autoxidation. During storage of used bleaching earth, the modified sterols were found to regain their original structure.

B. Edible Utilization

1. Selective hydrogenation. In basic studies on sorbic acid as a model compound, exchange of deuterium and hydrogen during homogeneous catalytic reduction with pentacyanocobaltate II was slow and incomplete. Exchange of deuterium with carbon-bonded hydrogen was observed only for the delta-carbon atom. In contrast, complete exchange and equilibration takes place over heterogeneous catalysts. Products of homogeneous hydrogenation of unsaturated fats with cobalt carbonyl resembled those obtained with iron carbonyl. However, during the reaction, there was much less accumulation of conjugated dienes, less selectivity towards linolenate, complete absence of monoene hydrogenation to saturates, less double bond migration and more trans isomerization.

Stable complexes of iron carbonyl and methyl linoleate have been isolated. These complexes hydrogenate rapidly, yielding monoenes and stearate, and also catalyze hydrogenation of methyl linoleate under milder conditions than those required with iron carbonyl catalysis.

In contract studies of heterogeneous catalysis at IIT Research Institute, the NMR method for determining 15,16 double bonds (developed at the Northern Division) has been adopted and found to give satisfactory results. Selectivity ratios of 3, compared to earlier values of 2, have been frequently observed with several metallic catalysts on molecular sieve supports.

At the University of Illinois, homogeneous catalysis of soybean oil esters and methyl linoleate has been achieved with platinum complexes of triphenylphosphine activated with hydrogen chloride and/or stannous chloride. These catalysts are selective in that hydrogenation does not proceed beyond monoene. However, conjugation and cis,trans isomerization take place.

Discovery of stable metal carbonyl-linoleate complexes and of several new homogeneous catalysts for hydrogenation of linoleate opens new possibilities for study that may lead to more effective control of the hydrogenation reaction. Observation of selectivities of 3 in heterogeneous catalysis is encouraging. This selectivity is approaching a value that might yield superior results in the hydrogenation-winterization process.

2. Improving flavor stability. Research on interesterification has demonstrated that soybean oil can be interesterified in the presence of immiscible extraction solvents and fractionation achieved on the basis of unsaturation in the rearranged triglycerides. Thus, potassium t-butoxide was found to be an effective interesterification catalyst for oils in an immiscible solvent mixture of acetonitrile, t-butanol and hexane. After reaction the acetonitrile phase contained more triene than before. Another effective solvent system was phenylacetonitrile-hexane. This solvent pair had a partition coefficient of 6.0, equivalent to an iodine value difference of 19 per theoretical plate. These results justify the basic rationale of the approach and provide a sound basis for future work.

Studies on solvent fractionation of hydrogenated-winterized soybean (HWSB) oil have been essentially completed. Liquid oil yields were 10 to 20 percent greater than those from conventionally fractionated HWSB oils. Yields of 90 percent liquid oil containing below 1 percent linolenic acid were obtained. Overall advantages of the present solvent fractionation technique, in comparison to conventional procedures, include ease of operation, increased yield of low-linolenic fraction, decreased yield of undesired saturated oil, and lower cloud-point of product.

3. Frying quality of soybean oil. In studies under a PL 480 grant at the University of Granada, Granada, Spain, it was found that students could not distinguish between soybean or olive oils used in frying potatoes. Also rats did not distinguish between potatoes fried in different fats. There was no correlation between palatability and fat penetration. Penetration of fats in chips and cubes differed for the same fat; but all fats tested differed in their kinetics of penetration.

4. Partial hydrogenation of soybean oil. Reduction of soybean oil was achieved with copper-chromium, copper-nickel, and copper-chromium-manganese catalysts. The best of these catalysts was reported, on the basis of activity, selectivity and cost, to be copper-nickel (95/5). Linolenic acid amounted to 1 to 2 percent at a level of hydrogenation suitable for preparing a hydrogenated winterized oil. This research is being conducted under a PL 480 grant at the Toyo University, Kawagoe, Saitama-ken, Japan.

C. Industrial Utilization

1. Oxidative cleavage of soybean oil and its fatty acids. Although methanol is an excellent solvent for ozonization, its volatility and solvent characteristics make it unsuitable for industrial use in this application. Laboratory studies of other solvents showed that a 50:50 2-methoxyethanol-acetic acid mixture gives aldehyde yields of 95 percent or more when the ozonolysis products were reduced by catalytic hydrogenation with a palladium-charcoal catalyst.

Engineering studies on preparation of methyl azelaaldehydate (MAZ) were directed towards establishment of conditions for catalytic hydrogenation of ozonized soybean oil methyl esters that would minimize formation of by-product dimethyl azelate (DMA). A MAZ-DMA ratio of 8, the highest so far observed, was obtained with a commercial Lindlar (Pb-poisoned Pd on $CaCO_3$) catalyst. Fresh catalyst and high catalyst concentration favored MAZ formation. Further study showed that, in addition to that formed during hydrogenation, a considerable quantity of DMA was present before catalytic reduction. It might possibly have formed during low-temperature storage of the ozonized soybean esters.

Improvements in color and viscosity of aldehyde oils were achieved by use of a better chemical reduction method and a high vacuum, short contact time, falling-film evaporator for removal of volatile aldehydic byproducts.

To obtain information on effects of metallic contaminants, a series of metals was tested for ability to catalyze polymerization of methyl azelaaldehydate. Copper and iron produced the most polymer; lead, zinc, sodium and aluminum were intermediate; and magnesium, calcium, nickel and chromium gave the least polymer. Cationic resins (H^+ form), which can be used to remove metallic contaminants, were found to effect conversion of aldehyde oils to acetals without alcoholysis of glyceryl ester linkages.

2. Aldehyde oil derivatives. In preparation of poly(ester-acetals) from isopropylidene glyceryl azelaaldehydate dimethyl acetal by the newly discovered hydrolysis-polymerization technique, it has been found that the polymer has a carboxylic acid end group formed by hydrolysis of the glyceryl ester. This hydrolysis is competitive with hydrolysis of acetal and ketal groups and terminates the polymerizing chain. Maximum molecular weight obtained so far is 1,540, representing 7 repeating units. When converted to the sodium salt, these polymers show moderate surface activity.

A glass coating showing excellent chemical resistance has been prepared from the poly(ester-acetal) of methyl azelaaldehydate, pentaerythritol and ethylene glycol. In studies on crosslinking of these films on glass, boron trifluoride is the best catalyst so far found that gives satisfactory films at moderate temperatures.

Cooperative studies with the Eastern Division on ester-acetals of azelaaldehydic acid as plasticizers for polyvinyl chloride showed that certain of these compounds have high compatibility and impart excellent low-temperature, mechanical, heat- and light-stabilizing properties to the plasticized polymer.

Study of preparation of 9-aminononanoic acid derivatives was initiated. Butyl 9-aminononanoate was obtained in 70-percent yield by high pressure catalytic hydrogenation of butyl azelaaldehydate in aqueous ammonia-ethanol solution. The excellent results achieved in these initial experiments indicate considerable promise for this route to intermediates for use in polyamides and polyesters.

3. Separation of fatty acids. Research under a PL 480 grant at the University of Helsinki, Helsinki, Finland, indicated that a chemical or physical change in unsaturated fatty acids or their methyl esters that occurs during zone refining may be one of the factors precluding effective separation by this means of polyunsaturated fatty acids derived from soybean or linseed fatty acids. The nature of the change is under study. Linolenic acid of 80 percent purity was obtained from linseed oil by a reasonable crystallization method and indications were that linoleic acid of comparable purity could be obtained from soybean oil.

4. New derivatives. Use of potassium deuterate in place of potassium hydroxide in the Varrentrapp reaction with 10-undecanoic acid has confirmed

the proposed mechanism of discrete steps involving intermolecular reversible 1,3 rearrangements of double bonds on the fatty chain. Other work supports the proposed mechanism for cleavage of the β-hydroxy fatty acid to acetic acid and fatty aldehyde of two less carbon atoms. Autoxidation of 9,10 (10,9)-hydroxyoxo stearic acid in ethanolic potassium ethoxide gave azelaic acid in 77 percent yield. Alkali fusion of 11-ethoxyundecanoic acid or of omega-hydroxy fatty acid gave good yields of the corresponding dibasic acid with no loss of carbon, and alkali fusion of 9,10-epoxystearic acid gave sebacic and suberic acids as the major dibasic products. These studies are in progress under a PL 480 grant to Queen Mary College, University of London, London, England.

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SOYBEANS
FEED, FOOD AND INDUSTRIAL USES FOR MEAL AND PROTEIN
Northern Utilization Research and Development Division, ARS

Problem. Production of soybeans continues to increase rapidly and exceeded 700 million bushels in 1963. For profitable disposition, now and in the future, of the growing supplies of meal from U. S. soybeans, improved feed products and new food and industrial uses are needed. Europe is developing a mixed-feed industry that needs high-protein concentrates. This market could approach that in the U. S. which uses high-protein meal from 450 million bushels of soybeans. For U. S. soybeans to achieve the maximum share of this market, more fundamental information is needed on the proteins and other nutritionally important constituents of soybeans and on the effects of processing on these components. Such information should make possible the production of feeds from soybeans having maximum feeding value that would meet the requirements of foreign markets as well as help maintain or increase the use of soybean feeds in the U. S.

U. S. soybeans could play a dominant role in alleviating the world shortage of dietary protein if more information were available on utilizing soybeans and soybean meal, flour, protein and protein concentrates in food products tailored to meet the nutritional and palatability requirements of foreign markets. That the possibilities are very real for increased utilization of soybeans in foreign food is indicated by recent work of the Department that showed how to use U. S. soybeans for Japanese foods. The result of this work was that a market for selected soybeans for Japan was opened that now exceeds one million bushels per year. If U. S. soybeans are to achieve the maximum share of foreign food markets, basic information on nutritionally important components and effects of processing on these components will be needed. In addition, better knowledge will be required of how to use soybean protein products in foodstuffs that will be acceptable abroad.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program involving organic and physical chemists and biochemists engaged in basic research on the characterization of components of soybean meal and protein and application of the knowledge gained to solution of problems encountered in processing and utilization of soybean meal and protein.

The Federal scientific effort on utilization of soybeans and soybean meal and protein totals 14.3 professional man-years. Of this number 7.2 are devoted to chemical composition and physical properties and 7.1 to food products.

Research at Peoria, Illinois, on chemical composition and physical properties (7.2 professional man-years) involves basic studies on isolation and

characterization of components of whey proteins and on heat gelation of alcohol-washed protein. During the reporting period compositional studies on acid-precipitated protein were discontinued.

Research at Peoria, Illinois, on food products (6.7 professional man-years) is devoted to development of information on specially processed soybean products pertinent to their use in high-protein foods for foreign markets. A research contract (.4 professional man-year) at the University of Illinois, Urbana, Illinois, is concerned with investigation of factors possibly present in soybeans that could cause digestive disturbances.

The current program at Peoria, Illinois, does not include research on industrial or feed products.

The Department also sponsors research on utilization of soybeans conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the University of Edinburgh, Edinburgh, Scotland, for investigations on polysaccharides of soybeans (4 years, 1960-1964); to the Weizmann Institute of Science, Rehovot, Israel, for research on complexes between soybean protein and other components of the meal (5 years, 1961-1966); to Kagawa University, Kagawa, Japan, for a chromatographic study of soybean sugars and oligosaccharides (3 years, 1963-1966); and to the University of Tokyo, Tokyo, Japan, for studies on soybean sterols (4 years, 1963-1967).

Research on food products involves grants to the Central Miso Institute, Tokyo, Japan, for studies on miso made from dehulled soybean grits (3 years, 1962-1965); Bar-Ilan University, Ramat Gan, Israel, for studies on miso-type food products for use in Israel (3 years, 1962-1965); Israel Institute of Technology, Haifa, Israel, for evaluation of the quality of isolated soybean protein for use in Israeli foods (4 years, 1962-1966); Japan Tofu Association, Tokyo, Japan, for studies on the use of U. S. soybeans for making tofu (2 years, 1963-1965); Institute of Chemistry, Academia Sinica, Taipei, Taiwan, for investigation on preparing Chinese cheese from soybeans (5 years, 1963-1968); and Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan, for studies on improved strains of Saccharomyces rouxii for making shoyu and miso (5 years, 1963-1968). Research under a contract, financed with PL 480 funds, has been completed by the Japan Shoyu Institute, Tokyo, Japan. The contract provided for comparative evaluations of soy sauces prepared from Japanese and U. S. soybeans.

Research on feed products involves a grant to the Hebrew University, Rehovot, Israel, for basic studies on soybean saponins (5 years, 1961-1966).

PROGRAM OF STATE EXPERIMENT STATIONS

The current station program involves both basic and applied research on soybean protein and meal utilization. Much of the basic research is aimed at characterization of soybean meal and protein. Applications of this

information to utilization is also made through several studies involving feed use of the meal. Basic studies seek to characterize the proteins and identify such biologically active components as proteolytic enzymes and their inhibitors. Other work is being directed to separation and identification of the proteins in soybean whey. Genetic effects as expressed in different varieties are being observed. Peptide structure of the individual purified proteins is investigated. Other researches involve study of the basic mechanisms of the biosynthesis of proteins.

In the area of food use, production of high-protein fermented foods such as tempeh from soybeans is the subject of a pilot study. This involves methods of processing, fractionating or modifying soybeans to produce low-cost, protein-rich foods of value for feeding infants and children.

Extensive economic feasibility studies are in progress. These range from use of meals in livestock feeds to the impact of the common market.

Total research effort devoted to soybean meal utilization is 4.8 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Acid-precipitated protein. In final phases of work on the major components of acid-precipitated soybean protein improvements were made in purifying the 11S, 7S and other globulins. Evidence was obtained that isolated soybean proteins contain carbohydrates, suggesting the presence of glycoproteins and/or carbohydrate-containing impurities. Because of the potential importance of heat-reversible soybean protein gels, which were discovered during the life of this project, emphasis was shifted at expiration of the project to basic studies on the heat gelation phenomenon.

2. Heat gelation of soybean protein. Initial work under this new project was devoted to further study of alcohol extractables of soybean protein since they appear to contain inhibitory material(s) that prevent formation of heat reversible gels from ordinary acid-precipitated protein. Components of the extractables identified so far include triglyceride, phosphatidyl choline, phosphatidyl ethanol amine, genistein, β-sitosterol-D-glucoside and saponins derived mainly from soyasapogenol B plus small amounts of soyasapogenols A and D.

When isoelectrically precipitated soybean protein was heated in 0.1N HCl, crystalline saponins separated. These were characterized by hydrolysis to soyasapogenols, glucuronic acid, hexoses and arabinose. Crystalline saponins have also been isolated from a number of commercial samples of soybean protein.

A large quantity (50 lbs.) of alcohol-washed protein was prepared for industrial evaluation. It gave a dispersion pH of 7 and a foam of good stability. Demonstration of the presence of saponins in commercial soybean protein suggests a possible basis for development of a method of detection and assay of soybean protein in food products. A successful method for this analysis should lead to increased use of soybean protein in food by eliminating a major problem associated with such use.

3. Whey proteins. Two additional trypsin inhibitors, designated B_1 and B_2, have been isolated from soybean whey. Characterization studies show that they differ from inhibitors A_1 and A_2. The total amount of the four inhibitors represents about 5 percent of the protein content of defatted dehulled meal.

Indications of appreciable varietal differences in trypsin inhibitor activity and in yield of isolatable protein have been obtained. Observation of these varietal differences is a significant discovery that could prove to have commercial importance in processing soybeans to food and feed products.

4. Soybean polysaccharides. Under a PL 480 grant, studies at the University of Edinburgh, Edinburgh, Scotland, on isolation and characterization of polysaccharides in soybean hulls are being completed, and a manuscript on galactomannans has been submitted for publication. Fractionation and characterization of polysaccharides in the cotyledon and germ components of the seed are underway. An extension of the work from 4 to 5 years has been recommended to complete planned studies.

5. Complexes of soybean protein with other meal constituents. During the reporting period work was concerned with the isolation and characterization of carbohydrate complexes with soybean proteins. Preliminary results obtained are very interesting and should yield valuable information about this type of soybean protein complex. This research is being conducted under a PL 480 grant by the Weizmann Institute of Science, Rehovot, Israel.

6. Soybean sterols. Scientists at the University of Tokyo, Tokyo, Japan, under a PL 480 grant, found that sterol glycosides isolated from soybean foots comprised a mixture of campesterol-, stigmasterol- and sitosterol-glycosides. The presence of campesterol-glycoside in soybeans has not been reported previously.

B. Food Products

1. Flavor and nutritive value of soybean food products. An improved taste panel procedure was devised for organoleptic evaluation of various soybean products. The new procedure showed that steamed and puffed soybeans had about the same intensity of flavor and were milder than soybeans treated with ultra-high frequency radio waves. Tasters preferred the steamed beans. Full-fat flour appeared to have the least flavor intensity when steamed

10-20 minutes. Alcohol-extracted flakes had a milder flavor than flakes steamed 20 minutes. Washing defatted meal with 80 percent ethanol or isopropanol was the most effective of many solvent treatments tested. Steam treatment of the washed meal gave a still more bland product.

The component(s) responsible for bitterness in the raw soybean was isolated and tentatively identified as a flavanone(s); a leucoanthocyanin may also be present.

Contract studies at the University of Illinois showed that flatus was produced by defatted soybeans eaten in biscuit form or by whole soybeans canned in tomato sauce. It was further shown, however, that alcohol-washed 70-percent-protein concentrate produces much less flatus per hour than dehulled defatted soybean meal. As a result of this apparent success in substantially removing the factor responsible for flatus production by soybean food products, it should now be feasible to isolate and identify the flatus-producing substance(s) and, therefore, to contribute to understanding of the biological mechanism of flatus production as well as to ultimately develop improved food products.

2. Full-fat soybean flour, UNICEF cooperative program. Accelerated storage tests at 100° F. showed that full-fat flour produced by the extrusion process had good stability for 9 months, corresponding to 1 to 2 years of storage at normal temperature. Vitamin assays showed that thiamine and niacin values were the same as for unprocessed flakes whereas values for commercial products were lower. Organoleptic tests gave preference to the extruded product over a commercial product toasted to the same NSI. Feeding tests with poultry indicated higher biological availability for methionine and cystine in the extruded product in comparison to a commercial full-fat flour.

All the results obtained to date are encouraging for the success of the extrusion process. Clinical tests of extruder-cooked soy flours in 1- and 2-year feeding programs for children up to one year of age were recently initiated in Taiwan and Indonesia under UNICEF sponsorship. If these tests are successful, it is probable that UNICEF will try out the process at overseas locations. However, considerably more study is needed to identify and evaluate the important parameters affecting the process. Such extension of our current work is especially desirable to make possible nutritious and palatable soy flour food products not only for infants but also for older children and adults in protein-deficient developing countries throughout the world.

3. Comparison of U. S. and Japanese soybeans for soy sauce. In studies under a PL 480 contract at the Japan Shoyu Institute, Tokyo, Japan, Japanese and U. S. soybeans were compared at 11 commercial processing plants located in different parts of Japan for quality and yield of shoyu. The results showed that U. S. commercial grade No. 2 soybeans produce shoyu that is equal in quality and slightly higher in yield than Japanese

beans selected for shoyu production. The reason for the higher yield was not determined. The lower cost of U. S. soybeans should give them a definite advantage over domestic Japanese beans. This work has been completed.

4. Studies on miso and tofu. Screening studies at the Central Miso Institute, Tokyo, Japan, indicated certain U. S. soybean varieties are preferable to others for the making of miso. Since proper color is an important characteristic of miso, considerable importance is associated with the cooking of the soybeans prior to fermentation. Harosoy is considered an excellent U. S. variety for making miso. The Japan Tofu Association, Tokyo, Japan, has made laboratory and commercial tests on 12 varieties of soybeans to compare their relative value for making Japanese tofu. The results showed that Hawkeye, Chippewa and CNS-4 gave the best quality and highest yields of tofu. Hawkeye rated somewhat better than the other two. The results for Jackson, Lee, Mandarin and Clark were not uniform enough for satisfactory evaluation and require additional study. Hill, Blackhawk and Comet varieties were found unsuitable for making tofu.

Results obtained at Bar-Ilan University, Ramat Gan, Israel, showed that a product similar in appearance and flavor to miso can be produced from soybean flakes. However, difficulties were encountered with surface growth of Aspergillus oryzae, an unexpected development. Investigations have been made of the use of enzyme preparations along with fermentation. This combination has resulted in a reduction in fermentation time.

At the Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan, research has been primarily devoted to a search for superior strains of Saccharomyces rouxii from various shoyu and miso fermentations. Three strains have been selected that give products with superior flavor. Additional selections have been made from the hundreds of isolates collected over Japan. However, some isolates are not Saccharomyces rouxii and it appears that any superior strains of other osmophilic yeasts should also be tested.

All of these studies were conducted under PL 480 grants.

5. Quality of isolated protein for use in Israeli-type foods. In studies under a PL 480 grant to the Israel Institute of Technology, Haifa, Israel, isolated soybean protein prepared by extracting defatted soybean flakes with 0.03M calcium hydroxide at 55° C. was found to be of high quality in respect to color, taste, and nutritional value. Use of isolated protein at the 40-percent level greatly improved the processing and quality of spray-dried bananas having enhanced flavor. Valuable information has been obtained on the effect of processing variables that affect the functional properties of isolated protein. Such detailed information has not been available heretofore.

6. Chinese cheese. Cultures suitable for preparing Chinese cheese (sufu) from soybeans were isolated from several sources, including strains found at each of the three factories making sufu in Taipei. These strains were evaluated with a laboratory-scale procedure developed for the purpose, and certain strains were sent to the Northern Division. From this work, it is apparent that the factories are actually using Actinomucor elegans although the organism previously had been thought to be a Rhizopus. When tested at the Northern Division, a very excellent product could be made using the laboratory method. This research is being conducted under a PL 480 grant by the Institute of Chemistry, Academia Sinica, Taipei, Taiwan.

C. Feed Products

1. Effects of saponins on nutritional quality of soybean feeds and foods. Scientists at the Hebrew University, Rehovot, Israel, found in studies conducted under a PL 480 grant that the isolated soybean saponins inhibited cholinesterase (i.e., killed fish), chymotrypsin, and proteases (in certain insect larvae). Controlled feeding of these saponins as well as feeding saponin-free soybean meal to mice lead to the conclusion that soybean saponins "are harmless even in concentrations much higher than those" found in the processed feed meal. The enzyme inhibitory effect of these saponins was fully counteracted by mixing them with soybean protein, which appears to complex them.

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REPLACEMENT CROPS
UTILIZATION POTENTIAL - NORTHERN REGION
Northern Utilization Research and Development Division, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the United States; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potentials. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants, and on byproducts from processing, such as oilseed meals.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a long-range continuing program of research involving analytical and organic chemists and chemical engineers engaged in examination of uncultivated plants to find unusual and potentially useful components and in detailed characterization and evaluation studies of selected components that have the greatest industrial potential and that are obtainable from agronomically promising plants. Plants or seeds for this program are obtained by cooperation with Crops Research Division which procures material from domestic and foreign sources by means of collecting

trips or from experimental plantings. Materials from abroad are also made available through Crops Research Division PL 480 projects providing for collecting activities by foreign investigators. All seeds and plants are submitted to a broad chemical-screening program to identify sources of unusual and potentially useful components such as oils, fibers, gums, amino acids and proteins. Components of interest from plants rated by Crops Research Division as having a reasonable agronomic potential for the United States are characterized to obtain clues to areas of utilization of probable interest to industry. On the basis of the results, plants having the highest agronomic potential and containing components of greatest potential industrial value are selected for more intensive utilization research. This utilization research is divided among the four Utilization Research and Development Divisions.

The Federal scientific effort devoted to research on replacement crops at Peoria, Illinois, totals 27.3 professional man-years. Of this number 16.0 are concerned with chemical composition and physical properties; 8.9 with industrial utilization of new oilseeds; and 2.4 with industrial utilization of new gum and fiber plants.

Research at Peoria, Illinois, on chemical composition and physical properties (16.0 professional man-years) involves conduct of the program on screening uncultivated plants for unusual and potentially useful oils, fibers, gums, amino acids and other components; organic chemical characterization of selected fractions and components, especially new oils and fatty acids; and studies on properties of new plant fibers. A research contract providing for screening and analysis of seed oils of Brassica (mustard) and related genera to identify species having greatest erucic acid content and agronomic potential was completed during the period by Montana State College, Bozeman, Montana.

Research at Peoria, Illinois, on industrial utilization of new oilseeds (7.3 professional man-years) involves studies on processing of erucic acid oilseeds to obtain oil and meal and investigations on utilization of erucic acid and its derivatives. A research contract (1.6 professional man-years) is in effect with Southern Research Institute, Birmingham, Alabama, for studies on preparation and evaluation of polyamide resins derived from crambe oil.

Research at Peoria, Illinois, on industrial utilization of new gum and fiber plants (2.4 professional man-years) is concerned with development of methods for recovery of gums from plants; with evaluation of plant gums in industrial applications; and with studies on pulping new fiber plants and evaluation of the pulp in paper, structural boards and related products.

The Department also sponsors research in this area conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the Institute of General Chemistry, Warsaw, Poland, for determination of glyceride structure of

erucic acid oils (5 years, 1962-1967); and to the Swedish Seed Association, Svalof, Sweden, to find new erucic acid oilseeds (5 years, 1963-1968).

PROGRAM OF STATE EXPERIMENT STATIONS

Discovery and preservation of valuable plant germ plasm is a continuing objective of the station program in new crops. Much of the research in this area is being done via four regional projects and in cooperation with regional centers. A large portion of the work is cooperative with USDA. Each year many plant introductions are grown and evaluated. Annual and perennial crops possessing potential for industrial or agricultural use are further evaluated for agronomic and chemical qualities. These include crops for paper pulp, drugs, insecticides, polysaccharide gums, and oils rich in acids of unusual structure. Assay of native and introduced tropical plants for products of economic value receives special attention.

Basic aspects of this program involve study of the biochemical and physiological bases for differences in crop plants. Attempts are made to determine if differences in biochemical or physiological processes can be associated with particular factors related to quality. Information concerning carbohydrate transformations is sought through study of carbohydrate formation and enzyme mechanisms.

Horticultural specialty crops are gaining in importance. A number of studies are underway to facilitate rapid development of this industry.

The total scientific effort devoted to replacement crops is 9.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Screening for new industrial oils. Since the last report, screening analyses were performed on 862 seed samples and 289 samples of oil were analyzed. Two new Crepis species contained 27-33 percent of the ene-yne acid first found in C. foetida. Seed oil of Sinapis arvensis, a mustard, contained 54 percent erucic acid--more than most rape and equal to some crambe. Of 29 species of Boraginaceae, 24 contained 6,9,12-triene and 6,9,12,15-tetraene in amounts up to 22 percent and 17 percent, respectively. Seed oil of a new annual species, Euphorbia lagascae, was found to contain 58 percent epoxyoleic (vernolic) acid. Oils from two species, Cardamine impatiens and Myrsinites africana, appear to contain more dihydroxy acids than has been found in other oils so far examined. This research is assuring a flow of new information for agronomists in selecting species for experimental plantings and for use in deciding upon possibilities for future preliminary developmental work.

Contract research at Montana State College has been completed. Six hundred samples were analyzed for erucic acid. These included 22 genera in the mustard family; however, most of the samples were Brassicas. Of the various species studied, B. campestris appeared to have the greatest promise as a producer of erucic acid. However, no species was found equalling crambe in erucic acid content and agronomic potential.

2. Characterization of new seed oils and components. The hydroxy acetylenic acid in Helichrysum oil has been shown to be the new compound 9-hydroxy-trans-10-octadecen-12-ynoic acid. The alkali isomerization product of cis-9-octadecen-12-ynoic acid (from Crepis foetida oil) was shown to be a mixture of trans,cis,trans and trans,cis,cis 8,10,12-octadecatrienoic acids. An acid (31 percent of total) in the seed oil of Calea urticaefolia has been characterized as trans-3, cis-9, cis-12-octadecatrienoic acid. Presence of the allenic grouping (C=C=C) in the dienoid acid of Leonotis nepetaefolia seed oil has been confirmed.

At the Institute of General Chemistry, Warsaw, Poland, under a PL 480 grant, studies are in progress on the triglyceride structure of high erucic acid oils. Oils from three seed samples from different plant sources have each been separated on alumina columns into five fractions, which appear to differ in fatty acid composition. A paper chromatographic procedure and pancreatic lipolysis are being applied to fractions obtained from the alumina columns to elucidate the structure of glycerides present.

3. Characterization of the components of crambe. The product formed by myrosinase hydrolysis of the major crambe thioglucoside has been identified as 5-vinyl-2-oxazolidinethione of opposite absolute configuration to goitrin. In addition to this oxazolidinethione (R-goitrin), 1-cyano-2-hydroxy-3-butene has been isolated and characterized as a second major breakdown product formed in some processed crambe meals. Still other products may be formed depending on conditions. Study of the crystalline protein or polypeptide from crambe seed showed that it comprises a single component having a molecular weight of 5,000 and containing no methionine.

Crambe seed lipase had little activity at room temperature in whole or crushed seed at moisture contents up to 13-15 percent. In samples of whole and cracked seed held at room temperature for 1 year, free fatty acid (as oleic) increased from 0.25-0.30 to 0.8 percent for whole seed and 1.0 percent for cracked seed.

The results of current studies on crambe thioglucosides and enzymes, and on the effects of various treatments of crambe meal emphasize the complexity of the problem involved in removal or deactivation of these physiologically active substances. Conditions have been found for making crambe meal that apparently contains no thioglucoside, oxazolidinethione or enzyme activity and has greatly improved feeding value. However, the nature of the conversion products that remain in the meal is unknown. Furthermore, there

is evidence showing the need for improved methods of analysis. Progress in this difficult field may not be rapid, but results achieved so far justify optimism that the problem will be satisfactorily solved.

4. Screening for new seed mucilages. Examination of 108 new species of seed revealed four species containing over 25 percent of water-soluble mucilage. These species are Cassia javanica, C. hirsuta, Trigonella arabica and T. gladiata. Evaluation tests showed that C. marilandica gum performed as well as guar gum as a wet-end additive in paper handsheets. Endosperm flour for evaluation studies was prepared by dry milling 50 pounds of C. occidentalis seed.

5. Screening for new pulp fiber plants. Statistical studies verified the effect of morphological and compositional differences on the pulping of mono- vs. dicotyledenous plants. Among new accessions in the screening program, a bamboo, Oxytenanthera abyssinica, received a favorable rating, but coastal bermuda grass (Cynodon dactylon), a plant having promising crop potential, had unfavorable pulping properties.

Study has been completed for 4 of 9 varieties of sorghum selected as promising pulping materials. Cellulose values for the four varieties studied were essentially equivalent to that of sugarcane bagasse, and the stalks contained less than one-third as much pith, which is favorable to use of sorghum. Pulps prepared from pith cells and core fibers, each a composite of the four varieties, gave similar handsheets which were, however, inferior in strength to handsheets made from pulp from unfractionated stalks of S. almum. Further mechanical processing and removal of fibro-vascular bundles from the core material provided much lower values for the true pith content of sorghum stalks than had been indicated by initial physical analyses.

As potential pulp crops, sorghums have advantages such as homogeneity in fiber length distribution, fair average fiber length, high yields in the field, light-colored outer bark, and composition resembling that of bagasse, an established raw material. They also have disadvantages such as high solubles content, leafiness, an average of 15 percent pith, and absence of any fibers as long as those of kenaf bast cells. Additional evaluation will be needed before the relative significance of these plus and minus factors can be appraised.

B. Industrial Utilization of New Oilseeds

1. Processing crambe seed. Commercial-scale processing of crambe seed was successfully accomplished when 36 tons of seed were processed by the prepress-solvent extraction procedure in the Sydney, Nebraska plant of Pacific Vegetable Oil Corporation. Engineering information obtained at the Northern Division enabled proper adjustment of the commercial equipment to secure very satisfactory operation. About 13 tons of toasted meal, 10 tons of crude oil and 8 tons of hulls were obtained. About 3.5 tons of

coarse foots, ordinarily recycled in full continuous processing, were also recovered. The oil was refined by PVO without difficulty and sent to the Northern Division for research and distribution for industrial evaluation. Defatted crambe meal prepared in the Northern Division pilot plant with a dry heat enzyme deactivation treatment was fed to lambs at the University of Illinois. Weight gains, digestibility and biological availability of protein were nearly equal to the soybean meal control. Palatability was poor but was improved by addition of molasses. No animals were sacrificed; however, there were no visual indications of toxicity. These results contrast with those of rat-feeding tests at the Western Division which showed that dry heat-processed meal was toxic to rats whereas meals produced by the enzymatic hydrolysis procedure or by methanol extraction appeared to be free of toxic effects in short-term feeding tests. In longer-term tests with rats and in chick feeding tests, somewhat poorer results were obtained. A cooperative agreement has been made with Nebraska AES for study of the feeding value for cattle of the meal obtained in the commercial-scale run at PVO.

2. Studies on utilization of erucic acid. Directed interesterification of crambe oil followed by low-temperature crystallization gave a fraction containing 78 percent erucic acid and representing 65 percent of the erucic acid of the original oil. Twenty diesters were prepared from brassylic acid obtained by oxidative cleavage of erucic acid. Tests of these diesters, conducted at the Eastern Division, indicated that brassylates are excellent low-temperature plasticizers for polyvinyl chloride. Morpholides and piperidides of pure erucic and of mixed crambe acids also were prepared for evaluation as plasticizers. In studies at the Southern Division, these derivatives showed good low-temperature properties and low volatility loss as plasticizers for vinyl chloride-acetate copolymer.

The encouraging results obtained in these utilization studies indicate that good prospects exist for developing new industrial uses for crambe oil and erucic acid.

C. Industrial Utilization of New Fiber Plants

1. Kenaf for pulp and paper. Continued progress is being made in optimizing techniques for preparing, handling, and using kenaf pulps. Comparative refining studies on kenaf, hardwood and softwood sulfate pulps showed that kenaf required significantly less time with either ball-mill or beater treatments. Improvements in preparing and handling kenaf mechanical pulps resulted in a cleaner product, pulps having controlled drainage properties, and avoidance of a byproduct problem. Complete characterization and pulping evaluation of two Nebraska-grown kenaf samples from 7- and 28-inch-row spacings disclosed no differences in pulping potential even though average stalk diameters were quite different in the two samples.

An industrial company is maintaining its interest in kenaf and has initiated plantings this year at seven locations in Alabama. Seed was furnished by Crops Research Division. Other firms have indicated interest in utilization of kenaf, including one concerned with development of harvesting machinery for new crops. If economics prove favorable, one of the more promising areas for commercialization of kenaf would be the South.

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PEANUTS PROCESSING AND PRODUCTS
Southern Utilization Research and Development Division, ARS

Problem. Peanuts constitute a major cash crop in the Southern States and are in surplus. Because of the high price of peanuts in the United States, peanuts are used almost exclusively (approximately 73 percent of the crop) in foods such as peanut butter, confections, and roasted and salted nuts. New type food products and improvement in the quality and uniformity of existing products are needed to increase consumer acceptance and extend markets; the average per capita consumption has been rather stable since World War II. The increased trend toward mechanical harvesting has necessitated the use of artificial means for curing and drying peanuts, with the result that processed peanuts and peanut products do not always possess the same desirable flavor and physical properties as peanuts which have been cured slowly in the field. Information is needed as to the physical and chemical characteristics of those chemical constituents in peanuts which affect the properties of processed products as a basis for developing new or improved products and processing procedures. Fundamental studies of peanut protein and associated materials could similarly lead to the development of new concepts and new uses. Additional information is urgently needed on the isolation, identification, evaluation, and control of mold toxins such as aflatoxin in peanuts and processed peanut products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving organic chemists and biochemists, engaged in basic studies on peanuts and peanut products to increase consumer acceptance and extend markets for peanuts.

Research to develop basic information on the chemical composition and properties of peanuts, its constituents, and processed peanut products is carried out at New Orleans, Louisiana. As a part of the Seed Protein Pioneering Research Laboratory's research on various seed proteins, fundamental investigations of peanut proteins and associated materials are conducted to form the basis for developing new concepts and perhaps new uses for peanuts and peanut proteins. In other in-house research, peanut constituents and their modification by processing that influence nutritive properties and consumer acceptance of processed peanut products are studied. Current phases of this research include investigations of the proteins and nonglyceride lipid-soluble constituents of peanuts and processed peanut products; and isolation, identification, evaluation and control of fungi and toxic fungal metabolites which may develop in peanuts and its processed products. The Crops Research Division of ARS, the Agricultural Marketing Service, and several State Experiment Stations cooperate in the research by providing samples of peanuts of known variety and history. The Pharmacology Laboratory at the Western Regional Research Laboratory, Albany, California, and the Food and Drug Administration cooperate in certain biochemical aspects of the research.

Additional research on chemical composition and properties is being carried out under contract at Evans Research and Development Corporation, New York, N. Y., on the isolation, identification and characterization of flavor and aroma components of processed peanut products; at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of the relation of the carbohydrate, amino acid and protein components of the peanut to the formation of flavor and aroma during roasting; at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, on a study of the limiting environmental conditions for the elaboration of mycotoxins in peanuts; and at the Agricultural Experiment Station, Texas A & M University, College Station, Texas, to develop information relating processing methods, preprocessing history, distribution of immature, mature and germinating peanuts, and external conditions such as mold incidence as they affect consumer-use properties of processed peanut products.

The Federal in-house scientific research effort in this area totals 7.4 professional man-years. All of the present effort is on chemical composition and physical properties. The contract research involves an additional 4.1 man-years, all of the effort being on chemical composition and physical properties.

PROGRAM OF STATE EXPERIMENT STATIONS

State stations have a continuing program of research directed toward increased use of peanuts. A portion of this effort is directed to fundamental studies on fermentation products produced by fungi growing on peanut substrates, including determination of the cultural conditions influencing the production of "toxins" by selected fungi growing on peanuts and peanut oil media. Other compositional research has as its objective the determination of the effects of storage environment and time on chemical, biochemical and physical changes in peanuts and the relationship of these changes to odor, flavor and certain nutritive factors. One study of the quality of peanuts and peanut products has been in progress over ten years. It involves determination of the effects of temperature, time, moisture conditions, storage and packaging on quality (staleness and rancidity development) in peanuts and peanut products. Other research supports the breeding programs through providing data on the susceptibility of various strains of Spanish peanuts to rancidity development.

Studies of the aroma and flavor of peanuts involve consideration of the agronomic and biochemical factors responsible for the flavor of peanuts and peanut butter. Attempts are made to characterize the substances responsible for the aroma and flavor peculiar to roasted peanuts.

Mechanization of peanut harvesting has led to renewed interest in peanut curing studies. Investigations aimed at developing more dependable and efficient methods for curing peanuts of high quality are in progress. Improvements in methods for measuring peanut maturity are sought The effects of various curing treatments are evaluated in terms of flavor,

adherence of the testa to the cotyledons, resistance to splitting and rheological properties of the peanut products. Influence of variety, stage of maturity and curing practices are also considered.

Development of products containing peanuts is pursued in an effort to extend the use of peanut butter, salted peanuts and peanut oil by improvement of present products or through development of new products. Nutritive value and consumer acceptability guide these researches.

The use of peanut oil meal as a source of protein for chicks is also being studied.

The station program on peanut utilization involves approximately 3.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical, Physical, and Biological Properties and Structural Factors of the Proteins. The composition, properties, structural factors, and reactions of the proteins and associated materials of various seeds, including peanuts, are being investigated in a program of pioneering research conducted by the Seed Protein Pioneering Research Laboratory. A major objective of this work has been to examine existing methods of classifying seed proteins and to provide the basis for development of new classifications having more meaning in terms of the function of the proteins in seeds. The present system of classifying seed proteins on the basis of solubility and the procedure of naming new proteins by trivial names has long passed its usefulness. Actually the name "seed proteins" is an anachronism that implies a mélange of proteins with many different structures and activities. This kind of a designation was made in the early days of biochemistry when people were beginning to catalog things as they observed them in organs, but as biochemistry progressed and specific activities could be attributed to various constituents, such catalogs disappeared. The one on seed proteins is one of the few remaining, probably because the seed is quiescent.

The proposed classification of seed proteins in storage tissue is based on their location in subcellular particles. Those in the particles have been named aleurins: proteins which occur in protein bodies in seeds, easily identifiable by electron microscopy and separable from other cellular particles or cytoplasmic proteins by suitable techniques. There would be a class of aleurins in Arachis hypogaea, another class in Pisum sativum, and another one in Gossypium hirsutum, etc. This new classification will influence new approaches in protein isolation based on particle separation; in one instance this has resulted in greater fractionation than was accomplished by the classical procedures. It also will speed up study of the biological properties of the major seed proteins and will promote interest in the ultrastructure of seeds. Many of the classical major seed proteins may turn

out to be primarily aleurins. It may turn out that some aleurins will have common functions and structure. These may be common to many seeds, or even to all seeds. Thus far, few proteins have been so handled as to fit into the category of aleurins. Some proteins of the peanut fit into this category; so do proteins from a particular fraction of pea cotyledons, and the acid soluble proteins of the immature wheat kernel.

Protein bodies occur in all storage tissues of seeds which have been investigated. It is the same whether the storage tissue is the cotyledon, as in legumes and cottonseed, or whether it is in the endosperm, as in grains, castor bean, and tung nut. This point was emphasized by a careful study of the ultrastructure of the storage tissue of four oilseeds: peanuts, cottonseed, tung, and castor.

Two subcellular particles were isolated from the cotyledon of the peanut (Arachis hypogaea): one contains 50 to 55% protein and about 10% lipid and and a second, lighter particle, which is stable at pH6, contains almost half and half proteins and lipids. The latter particle also has measurable phosphatase activity. The proteins of these two particles were studied by chromatography on DEAE cellulose. Most of them are predominantly group IV proteins; these are the aleurins of the peanut cotyledon; these are the same as the classical arachin fraction. This work demonstrates another virtue of the particle approach, because it was possible to fractionate the major proteins of the arachin fraction by fractionating the two particles: two fractions which chromatographed differently on DEAE cellulose were obtained.

A careful study was made of the development of protein bodies in the cottonseed (Gossypium hirsutum) at the level of ultrastructure. Two points seem to be clear. First, there is a single membrane around protein bodies in immature cottonseed cotyledons. Other investigators, studying wheat endosperm, have suggested that the protein bodies have a double membrane. This is an important issue in classification. If protein bodies have a single membrane, they are in the same class as vacuoles; if there is a double membrane, they are in the class of plastids. The evidence here would seem to be that they are in a class of vacuoles. Secondly, the proteins seem to be synthesized by extending part of the endoplasmic reticulum in a loose large body surrounded by a single membrane; this body becomes smaller as the seed matures. There is no evidence that the major protein bodies are accumulated by mechanisms similar to those which operate in the pancreas, that is, by the use of the Golgi apparatus.

Important new equipment and techniques have recently been developed to facilitate the study of proteins. Progress has been made in understanding the characteristics of polyacrylamide gel and in transforming it into a sensitive column electrophoresis medium, both for analysis and preparation. Two major operational problems were solved. The first was the stabilization of the gel. Since the gel expands in certain buffers, it is not possible to continue electrophoresis for a long period. It is not clear why the gel expands; it could partly be due to electroendosmosis. It was discovered

empirically that a mixture of tris and phosphate buffers incorporated into the gel medium will stabilize the column; this stabilization is independent of the buffers used in the electrode chambers. The other question was that of yield. Because most of the protein adhered to the cellophane membrane between the column and the anode, yields up to only 30% were obtained at first. This problem was solved by treating electrically charged membrane as if it were permanently charged as, for example, DEAE cellulose, and increasing the salt concentration in the wash. Now yields of 80 to 100% are regularly obtained.

Another useful tool is the study of enzymes by calorimetry. Phosphatase activity is usually measured by taking aliquots during the course of a reaction and determining the amount of inorganic phosphorus released. This reaction cannot be followed continuously. But by taking advantage of the heat of the reaction, it is possible to follow phosphatase reactions by calorimetry from the beginning to the end. This procedure was tested on various phosphatases: potato apyrase, the transport phosphatase of red blood cell ghosts, and a phosphatase from germinating peanut seeds. When the enzyme is acting as a phosphatase without any transport properties, it produces a calorimeter pattern different from that produced when it is acting as a transport phosphatase. Hence, calorimetry has introduced a new dimension in study of enzyme reactions.

Further work on the biochemistry of seeds and their proteins strengthens the notion that seeds are useful models for important biological studies: studies on active centers of enzymes, isolation of cofactors for lipases, changes in ribosomes with state of tissue, and studies in protein synthesis.

It is generally considered that transport of sodium and potassium across membranes is mediated by an adenosinetriphosphatase (ATPase) which is inhibited by the cardiac glycoside, ouabain. All of the work on this enzyme was originally from animal tissues. Such a transport enzyme was isolated in germinating peanut seeds; it responds to changes in sodium, potassium and magnesium concentration; moreover, its activity is affected by ouabain. Here is another instance of the universality of certain basic biological mechanisms and another indication of the possibility of using seeds to study fundamental biological problems.

The castor bean lipase as studied to date is particulate. It was solubilized by incubation at controlled pH, apparently by the action of a proteolytic enzyme contained in the particulate material. It is now completely soluble and can now be purified by standard techniques. The natural cofactor of castor lipase was found to be a cyclic polymer of ricinoleic acid. Other lipid materials which can act as cofactors include ricinoleic acid, oleic acid, monoricinolein, tocopherol succinate, and the methyl half ester of dodecenyl succinate. It is interesting that most compounds with cofactor activity have a free carboxylic acid and a long hydrophobic chain.

There is no information on whether resting seeds contain ribosomes.

Certainly they exist in the actively developing seeds and exist again in the germinating seeds. By taking advantage of work previously done in this laboratory on nonaqueous fractionation of peanuts, a fraction high in nucleic acid was used as a starting material from which were isolated ribosomes, both in cottonseed and peanut cotyledons. The ribosomes from the two seeds are the same; they have a sedimentation value of 80S and are sensitive to magnesium concentration. They appear similar in physical and spectroscopic properties to ribosomes from other tissues. Isolation of ribosomes from the resting seeds provides a good ground state source of ribosomes, that is, a source of ribosomes from tissue in which little, if any, protein synthesis is taking place. It will be interesting to compare the properties of these ribosomes to those in developing and germinating seeds.

In a new line of research, it has been shown that cyclopropene fatty acids inhibit the sulfhydryl group of an SH-sensitive enzyme, castor bean lipase. Lipids containing cyclopropene fatty acids, including certain cottonseed oils and the oil from Sterculia foetida, when fed to hens or to other animals, have been reported to disturb the metabolism of lipids, change the properties of the vitellin membrane, and increase the ratio of stearic to oleic acid in the tissue fat. Castor bean lipase, which had previously been shown at this laboratory to be sensitive to sulfhydryl reagents, was used to test a suggestion in the literature that cyclopropene compounds may react with sulfhydryl compounds to form stable derivatives containing thioether bonds. Sterculia foetida oil inhibited castor lipase, and cottonseed oils containing higher amounts of cyclopropene fatty acids were hydrolyzed at a lower rate than were oils containing a lower quantity, such as refined oils. That the cyclopropene moiety was responsible for these effects was clearly demonstrated when sterculene, a synthetic cyclopropene derivative, was also shown to inhibit the castor lipase. Since these natural oils containing cyclopropene fatty acids have some properties analogous to those of substrates for the enzyme, this work may support the theory that the physiological activity of cyclopropene fatty acids is by way of their reaction with the functional sulfhydryl sites of enzyme systems. It will be interesting to continue studies on the inhibition of a purified soluble castor lipase, which may be a means of labeling the sulfhydryl group responsible for the activity of the enzyme.

2. Identification of Constituents and Factors Influencing Flavor, Aroma, Color, Structure, and Nutritive Value of Processed Products. Further progress has been made in isolating and characterizing minor constituents of peanuts and in establishing their physiological activity. Three additional products have been isolated from defatted peanut flour. A new amino acid, N-methylhydroxyproline, was isolated and characterized--the first report of this amino acid as a constituent of an edible product. It is probably a methyl donor; if so, it could play a significant role when peanuts are used as food. Also isolated from the flour was pipecolic acid, which is also of potential importance since it is probably involved in the metabolism of lysine. A peanut factor is known to play a role in reducing bleeding time, especially in hemophiliacs. Another constituent isolated, apparently a

purine, causes marked relaxation of excised smooth muscle. This myotonic factor in peanuts -- which may be related to the hemostatic factor -- apparently is a coenzyme involved in the release of energy in the transformation of adenosine triphosphate to adenosine diphosphate, not only in muscle contraction but also in the formation of fibrin from fibrinogen and in the agglutination of the blood platelets.

Because of their potentially marked physiological activity, these minor constituents may be of considerable significance and importance to the role of peanuts in the human diet. This research project has been terminated and available personnel are being utilized to augment research on fungi and toxic fungal metabolites in peanuts. (S4 1-100).

In an investigation complementary to the preceding work, basic research on the nonglyceride lipid-soluble constituents of peanuts has been continued. Solvent fractionation and chromatographic separation of nonglyceridic components from the bulk of the triglycerides was investigated. Column chromatographic procedures proved feasible for separating crude commercial peanut oil into a series of simple mixtures but have not yet been successful for the preparation of pure compounds. Partition of the crude oil between hexane and acetonitrile was found to result in considerable enrichment of three or four of the nonglyceride components in the acetonitrile phase. Emphasis will be placed on the components in the acetonitrile extract. By a combination of solvent partition and column and/or thin layer chromatography, it should be possible to obtain sufficient amounts of lipid-soluble peanut constituents for instrumental examination. Volatile fractions will be investigated by gas chromatography. (S4 1-109).

The contractor (Evans Research and Development Corporation) is conducting research on the isolation, identification, and characterization of flavor and aroma components of processed peanut products to form the basis for producing improved peanut products of greater consumer acceptability. Preliminary experiments revealed that steam distillation at atmospheric pressure was not satisfactory for concentrating a "true" peanut aroma. Hexane extraction, however, yielded a concentrate rich in peanut aroma.

Modification of the solvent extraction procedure achieved convenient extraction of large quantities of peanuts and rendered subsequent fractionations more complete. High grade, medium roasted peanuts (Spanish, including southwestern-grown, and either Virginia or Runner type) are being used in the research. Thus far, two aldehydes -- 2,4-decadienal and hexanal -- have been identified in a neutral oil fraction, and acetic and isovaleric acids in an acid fraction. A third acid is either propionic or isobutyric acid, and a fourth one is probably a branched-chain, seven carbon acid. The identification work is continuing. Investigation of flavor precursors in raw peanuts also is in progress. (S4 1-106(C)).

3. Investigation of Occurrence, Determination, and Properties of Fungi and Toxic Fungal Metabolites Which may Develop in Peanuts and Their Processed

Products. The problem of agricultural commidities' becoming contaminated with toxic microbial metabolites is receiving increasing recognition. To determine the prevalence of such contamination in peanuts, two surveys based on chemical assay are currently being conducted. For the first test, the Biometrics Service of ARS designed a sampling plan in which a cross section of the 1963 crop from warehouses storing CCC's stock was analyzed by Southern Division scientists using their own new technique, which is sensitive to an aflatoxin content of 2-3 parts per billion. Sampling included 5 states, 3 types of peanuts, and 4 classifications; results from 137 samples indicate correlation between quality classification and presence and degree of contamination. The data obtained are of particular and immediate value, in that they supply good leads toward methods for eliminating contaminated peanuts from food channels and furnish a basis for the development of an orderly marketing program for the 1964 peanut crop. The second test, on stocks of No. 2 peanuts, is presently being performed in cooperation with other groups, all of which use the same sampling and analytical procedures sensitive to 50 parts per billion, the limit of sensitivity of present bioassay procedures.

In addition to the two chemical assays, extensive animal feeding tests are being conducted: aflatoxin-free meals, meals containing aflatoxin, and a mixed solvent extract of an aflatoxin-containing meal have been sent to the Pharmacology Laboratory, WU, to determine the effect of aflatoxin in peanut meal rations.

The method of extracting aflatoxin developed by Southern Division scientists employs a solvent mixture composed of acetone, hexane, and water. The same mixture has also been found to remove aflatoxin from contaminated peanut meal. Since aflatoxin can readily be removed from oil by conventional refining procedures, this mixture may become the solvent of choice in commercial processing of peanuts to oil and aflatoxin-free meal. (S4 1-116).

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TUNG PROCESSING AND PRODUCTS
Southern Utilization Research and Development Division, ARS

Problem. Tung oil has lost much of its traditional market in protective coatings to synthetic raw materials. New and improved industrial products from tung oil must be developed to recapture lost markets, maintain present markets, and provide new outlets for surplus tung oil. Basic information is needed on the chemical composition and properties of tung oil and its fatty acids, and on the chemical modification of these materials to permit more effective exploitation of their unique characteristics in protective coatings, agricultural and industrial chemicals, surfactants, and plasticizers. For example, improved coatings utilizing tung oil are needed to meet increased performance demands and competition from synthetic polymeric coatings. Intumescing fire-retardant coatings and water-reducible coatings containing tung oil are desired. A limited market of low economic value exists for tung meal as a fertilizer. Research is needed to develop more information on profitable uses of tung meal to benefit the overall economy of the tung industry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving organic chemists engaged in both basic and applied research on tung and its products. Emphasis in the present program is on development of new and improved industrial products from tung oil and its derivatives.

Research is conducted at New Orleans, Louisiana, to develop fundamental information on the chemical composition, properties, structural factors, and reactions of oilseed proteins, as a basis for development of new concepts and possibly new uses for oilseed proteins.

Research to develop new and improved industrial products from tung oil is carried out at New Orleans, Louisiana, with cooperation and support by the Pan American Tung Research and Development League and the U. S. Army Engineer Research and Development Laboratories. The League maintains a part-time Fellow for research on the production of improved protective coatings. Major emphasis is placed on the development of exterior and interior, intumescing, fire-retardant surface coatings from tung oil and tung oil derivatives. Tung alkyds are being chemically altered and formulations modified to produce coatings which will intumesce to give a thick cellular, fire-resistant material upon thermal or flame exposure. The U. S. Army Engineers evaluate the more promising fire-retardant coating formulations developed with their support.

Other research in the area of chemical composition and physical properties is in progress under a grant of P.L. 480 funds to the National Chemical Laboratory, Poona, India, for investigations of the effect of heat on tung oil and its derivatives, and characterization and identification of compounds

resulting from heat treatments, to extend the utilization of tung oil (project duration - 5 yrs.).

The Federal in-house scientific research effort in this area totals 4.9 professional man-years. Of this total 0.7 is devoted to chemical composition and physical properties, and 4.2 to new and improved industrial products. P.L. 480 research involves 1 grant for research on chemical composition and physical properties.

The following line of work was terminated during the year: (1) Chemical modification of tung oil and its fatty acids to produce materials having potential industrial utility (under new and improved industrial products).

PROGRAM OF STATE EXPERIMENT STATIONS

State stations did not report work in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Structural Factors, Properties, and Reactions of the Protein. The composition, structural factors, properties, and reactions of oilseed proteins and associated materials are being investigated in research conducted by the Seed Protein Pioneering Research Laboratory. The basic information developed should lead to new concepts and possibly new applications for oilseed proteins, including tung protein. Since peanuts were found to be a particularly suitable experimental material and were employed for much of the early pioneering research on seed proteins, the report of progress in this research is given in Area No. 7, "Peanuts Processing and Products," as in the previous report.

2. Basic Investigations of the Effect of Heat on Tung Oil and Its Derivatives. At the National Chemical Laboratory in Poona, India, research to investigate the effect of heat on tung oil and on its derivatives has been initiated under a P.L. 480 grant. Compounds resulting from subjecting these compounds to heat will be identified and characterized. The early stages of the work have been confined to methyl esters of alpha- and beta-eleostearic acid. A chromatographically pure cyclic monomer has been isolated from methyl alpha-eleostearate thermally treated in an evacuated sealed tube. The fundamental information generated by this research is expected to aid in the development of new industrial uses for tung oil outside the protective coatings field. (UR-A7-(40)-12).

B. New and Improved Industrial Products

1. Intumescing Fire-Retardant Surface Coatings from Tung Oil Alkyds. Considerable progress has been made in the development of water-resistant, intumescing, fire-retardant coatings based on tung oil and its derivatives,

research conducted with the cooperation and support of the U. S. Army Engineer Research and Development Laboratories and of the Pan American Tung Research and Development League. Use of the elementary 8-foot tunnel furnace devised at the Southern Division to screen experimental coatings has provided insight into the reasons that an early formulation which performed well in the standard fire test cabinet did not do so in the Underwriters' Laboratories' 25-foot tunnel furnace. From these observations, experimental formulations have been developed to eliminate the excessive blistering, rupturing, and peeling of the earlier coatings. The newer coatings, formulated from vehicles based on chemically-modified tung oil and from chemically modified, water-resistant carbonific and spumific components, intumesce under heat to produce an insulating layer of carbonaceous material. The two formulations that performed best in the 8-foot tunnel furnace also gave encouraging results in the 25-foot tunnel furnace: one had a respectable flame spread value of 40; the other, between 45 and 55 -- significantly better than the value of 85 exhibited by earlier coatings tested in the UL furnace. As far as known, there are no practical commercial, water-resistant, fire-retardant coatings available with such low flame-spread values. However, attempts will be made to further improve the new formulations, including lowering their flame-spread values to 25 if possible. There has been considerable industrial interest in such coatings, which have potential for commercial, civilian, and military use. (S4 1-113).

2. Chemical Modification of Tung Oil to Produce New and Improved Products, Such as Protective Coatings, Agricultural Chemicals, Surfactants, and Plasticizers. Several approaches for chemical modification of tung oil and its fatty acids to produce materials having industrial utility were investigated. In further research on reactions to improve the surfactant or emulsifier properties of tung oil products for use as fugitive emulsifiers, difficulty was encountered in attempts to prepare the nitrile from eleostearic acid by reaction with ammonia. The carboxyl group was modified only to the amide stage, and eleostearate unsaturation was reduced considerably. However, recent experiments have resulted in the successful preparation of ethenoxylated monoglycerides of tung oil with retention of the conjugated triene unsaturation of the eleostearate moiety. This result could lead to improved fugitive emulsifier products from tung oil. In the reaction employed, tung monoglycerides are reacted with ethylene oxide using bis(2-methoxyethyl) ether as solvent, catalytic amounts of metallic sodium, temperatures close to 150° C., pressures of 1/2 to 1 atmosphere above atmospheric, and short reaction times. The products are mixtures of materials containing on the average 1-4 moles of ethylene oxide per mole of tung monoglycerides, the average amount of ethylene oxide reacted depending on the pressure and length of the reaction time. (S4 1-93).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

New and Improved Industrial Products

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1/ Publication resulting from research supported in part by funds transferred from the U. S. Army Engineer Research and Development Laboratories.

REPLACEMENT CROPS - UTILIZATION POTENTIAL

Southern Utilization Research and Development Division, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) Survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the U. S.; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy unsaturated acids, capric acid, epoxidized acids and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants and on byproducts from processing, such as oilseed meals.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving organic and analytical chemists engaged at New Orleans, Louisiana, in research to develop and evaluate industrial chemical products from the oils of certain new oilseed crops having production potentials as replacement crops. Oils from the seeds of the plants Limnanthes and Cuphea, rich in unusual long-chain unsaturated acids and capric acid, respectively, and from seeds of Umbelliferae such as parsley, carrots, fennel, dill, and coriander containing high percentages of petroselinic acid, are currently being investigated. The research is concerned with chemical modification of the oils and their

fatty acids to produce materials having potential utility in plastics, plasticizers, synthetic rubbers, protective coatings, and other industrial products. Research has been initiated to determine the chemical characteristics of juices obtained from selected new varieties of sweet sorghum canes grown in the Rio Grande Valley of Texas; and to determine the effects of cultural and harvesting practices on these chemical characteristics in relation to suitability for sugar recovery.

Close cooperation is maintained with the New Crops Research Branch, Crops Research Division, in the procurement of seed and in joint evaluation of the potential of the new crops. The Pharmacology Laboratory of the Western Division, Albany, California, performs tests as needed to determine the physiological properties of the oils, their derivatives, and the meals. Louisiana State University cooperates by testing some of the chemical derivatives for antimicrobial activity. Other appropriate agencies in the Department of Agriculture and the State Agricultural Experiment Stations cooperate by evaluating the utility of some of the new compounds prepared from the oils. Informal cooperation is also maintained with industrial firms for evaluations of promising materials developed in the research. In research on sorghum cooperation is maintained with substation 15, Texas Agricultural Experiment Station, Weslaco, Texas, and Crops Research Division, ARS.

The Federal scientific effort at the Southern Division devoted to research in this area totals 8.0 professional man-years. Of this total 2.3 is devoted to chemical composition and physical properties and 5.7 to industrial utilization.

PROGRAM OF STATE EXPERIMENT STATIONS

Discovery and preservation of valuable plant germ plasm is a continuing objective of the station program in new crops. Much of the research in this area is being done via four regional projects and in cooperation with regional centers. A large portion of the work is cooperative with USDA. Each year many plant introductions are grown and evaluated. Annual and perennial crops possessing potential for industrial or agricultural use are further evaluated for agronomic and chemical qualities. These include crops for paper pulp, drugs, insecticides, polysaccharide gums, and oils rich in acids of unusual structure. Assay of native and introduced tropical plants for products of economic value receives special attention.

Basic aspects of this program involve study of the biochemical and physiological bases for differences in crop plants. Attempts are made to determine if differences in biochemical or physiological processes can be associated with particular factors related to quality. Information concerning carbohydrate transformations is sought through study of carbohydrate formation and enzyme mechanisms.

Horticultural specialty crops are gaining in importance. A number of studies are underway to facilitate rapid development of this industry.

The total scientific effort devoted to replacement crops is 9.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Industrial Utilization

1. Industrial Products from Oilseeds Containing Capric Acid or Unusual Long-Chain Unsaturated Acids. Seeds of the potential replacement crops Cuphea, Limnanthes, and Umbelliferae are being studied with respect to the chemical modification of their oils and fatty acids to produce materials used in plastics, plasticizers, synthetic rubbers, protective coatings, and other industrial products.

In work on chemical derivatives of capric acid (the major constituent of Cuphea seed oil), treatment of 2-bromodecanoyl bromide with potassium hydroxide in alcoholic solutions afforded products (2-decenoic, 2-hydroxydecanoic, and 2-ethoxydecanoic acids) that may have antimicrobial activity. In preliminary tests, the former two agents have shown good inhibition against several organisms. A number of chemical derivatives of capric acid and other medium-chain acids have been prepared in sufficient quantity for evaluation as pesticides by the Entomology Research Division. Included are 4-(2-octenoyl)-, 4-(2-nonenoyl)-, 4-(2-decenoyl)-, 4-(2-dodecenoyl)-, 4-(2-bromodecanoyl)morpholides, and propargyl 2-bromodecanoate.

Research on isolating the component acids of Limnanthes douglasii oil has been facilitated by development of a method for the rapid gas-liquid chromatographic analysis of the methyl esters of the component acids. Methyl eicosenoate -- the methyl ester of the principal component acid -- has been produced in a 90% pure form from the mixed methyl esters by distillation techniques, and methyl docosadienoate has been isolated by means of fractional crystallization-adsorption chromatography. No catalysts have been found which are significantly more effective than p-toluenesulfonic acid for the lactonization of eicosenoic acid.

The preparation of nitrogen-containing derivatives of petroselinic acid, a major acid of Umbelliferea seed oil, has been improved and a continuous process devised in which petroselinic acid is subjected to ammonolysis and further modified to yield the final product, such as petroselinylamine or its derivatives, N-petroselinyl-1,3-propylenediamine, and N,N-bis(hydroxyethyl)petroselinylamine, without isolation of the intermediate. These compounds will be examined for their antimicrobial activities and also evaluated as corrosion inhibitors. A method was developed for preparation of the vinyl ester of the adduct of petroselinic acid and hexachlorocyclopentadiene. The ester is to be tested as a copolymer for vinyl chloride in plastics. Attempts to separate the aldehydes obtained from reductive ozonization of methyl petroselinate by fractional distillation gave more than one-half of the lauraldehyde practically free of

adipaldehydate, but all adipaldehydate fractions contained some lauraldehyde. The development of a good method of separation is important since many of the suggested uses for petroselinic acid depend on the reactions of these aldehydes. A method for determining percent petroselinate in the presence of oleate, based on reductive ozonization of the methyl esters and analysis of the resulting aldehydic fragments by gas liquid chromatography, appears promising for application to the analysis of fennel seed acids. A potentially useful polyol, trimethylol undecane, has been prepared in 30 to 35% yield by reductive ozonization of petroselinic acid and subsequent treatment with alkali and formaldehyde. Although the present project has been terminated, promising leads will be investigated under a new project. (S5 5-45).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

None

CASTOR, SAFFLOWER, AND OTHER WESTERN OILSEEDS - PROCESSING AND PRODUCTS

Western Utilization Research and Development Division, ARS

Problem. To provide valuable diversification crops for the acreage withdrawn from the production of cotton, wheat, feed grains, and other surplus crops, we must expand the markets for crops such as castor and safflower. Large amounts of safflower are exported and research is needed to insure the continuance and expansion of this promising market. Also, these crops are so new to our agricultural economy that their market potential has not been adequately developed. Castor and safflower have good potential because of the unusual properties of their oils. The possibility of large-scale increases in the production of these oilseeds would be strengthened if high-quality feed products could be developed from the oilseed meals. Basic information is needed on the composition of the oils and of the meals left after extraction of the oil, and this, in turn, requires the development of adequate analytical methodology. Rapid and accurate analytical methods are needed to control and improve the processing of the oils and meals for food, feed and industrial applications. Research on chemical conversion of the oils and evaluation of the modified products is needed to find new or improved large-volume uses. The high percentage of linoleic acid (essential fatty acid) in safflower oil points to a rapidly expanding use as a food oil. But this same fatty acid imparts a high susceptibility to autoxidation. Research is needed to stabilize safflower oil in various food products. Improved procedures for decorticating and processing castor and safflower seeds are needed. There is a particularly critical need to remove or destroy the allergenic and toxic components of castor meal which presently limit its use to fertilizer. Research to isolate and characterize the constituents in castor and safflower meals is needed to develop non-toxic, non-allergenic feed and food products of high value. Particular emphasis should be placed on developing safflower meal suitable for human consumption, opening an entry into the increasing edible protein export market. Basic and applied research is needed to prepare chemically modified products from the meals for industrial applications, to develop economical procedures for carrying out the modifications, and to evaluate the modified products.

USDA AND COOPERATIVE PROGRAM

In the Western Utilization Research and Development Division, both basic and applied research are conducted on castor and safflower seed at the Division headquarters at Albany, California and, under contract, at Tucson, Arizona, and by P.L. 480 grant funds in India. Basic, compositional studies on castor seed meal are concerned with the resolution of its water-soluble proteins and determination of the allergenic and antigenic properties of these components. Studies are conducted on the composition of castor and safflower oils and meals, and new analytical techniques are developed.

Applied research on castor meal has as its objective the development of economical methods for deallergenizing the meal without impairing its nutritive quality, to increase its value as an animal feed ingredient. Castor oil and its major constituent, ricinoleic acid, are being studied to provide for them new and improved industrial applications. Thus, methods are being developed for the preparation of various types of polyurethane foams incorporating castor oil or its derivatives. Procedures are also being devised for the preparation of chemical derivatives of ricinoleic acid, including a number of amides and phosphate esters. Several of the latter compounds may be useful for improving the flame-resistance of castor-based polyurethane foams of the type which may be used for building insulation. The utility of various polymerizable monomers from castor oil for the production of synthetic polymers for use in rubbers, plastics, etc., is being investigated under contract. Research has been initiated on the composition of new and commercially promising safflower varieties. Detailed studies are underway to evaluate variation of fatty acid, amino acid, protein, fiber, etc. with the types of seed. Oils from new and established varieties are being studied for oxidative stability which is needed for large-scale food uses. The meals are being evaluated as protein sources in animal rations. Research under contract is anticipated on the types and amounts of natural antioxidants in the various safflower seed oils.

The Federal program of research in this area totals 11.7 professional man-years, including contract research equivalent to approximately 0.7 professional man-years per year. Of this total 6.9 are assigned to chemical composition and physical properties; and 4.8 to new and improved products and processing technologies. In addition, one grant on basic studies is sponsored under P.L. 480.

PROGRAM OF STATE EXPERIMENT STATIONS

Castor and safflower are of interest due to the unusual properties of their oils and as possible replacement crops. State stations are investigating agronomic and harvesting problems. Utilization research is limited to nutritional and chemical evaluations of the castor plant being done in cooperation with USDA. Objectives include study of: the toxic and hemagglutinating protein, ricin; use of castor meal as a supplemental feed for large animals; the role of ricinine in metabolism and physiology of the plant; and isolation and identification of the compound(s) responsible for the foaming of aqueous extracts of castor beans.

There are approximately 1.8 professional man-years devoted to this study.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Detection of Allergens. A risk-free and highly specific test for human allergy, with far-reaching implications for future medical practice and

research, was reported last year as a development in the control of allergenic properties of castor seed proteins. The use of monkeys materially reduced the cost of allergy testing and, more important, eliminated hazards to human volunteers. Two hundred patients of Dr. Raphael Panzani of Marseilles, France were used in cooperative studies to indicate the extent of deallergenization of castor pomace. These studies made it possible to learn the maximum permissible level of allergen and to hyposensitize, with castor pollen extracts, patients living in the castor processing areas or on farms that used castor fertilizer. The hyposensitization allows these people to avoid suffering from allergic attacks.

Preliminary work demonstrated no cross reactions between castor allergy and chlorogenic acid allergy. The presumption of such cross reactions, as published by other workers in this area, appears to be false. Marmosets were demonstrated to be useful in the study of human castor bean allergy by the allergic serum transfer test. Since these animals can be purchased for a quarter of the price of macaques and can be kept in small animal cages in chemical laboratories or rat laboratories, this finding should make it easier for other research laboratories to enter into this type of investigation.

2. Oilseed Components. Analytical studies were initiated on 24 safflower seed samples obtained from industry, academic sources, and Crops Research Division personnel. They included the leading commercial and several new commercially promising varieties. Hull content of these safflower seeds ranged from nearly 60% for one wild variety through 40% in a typical commercial variety to 18% in experimental thin-hulled varieties. Meal and oil content of these safflowers varied inversely with the hull contents. Thus, the wild variety had only 15% meal and 30% oil while the thin-hulled experimental variety had 34% meal and 45% oil. Fatty acid analyses of the oils from these various samples are being determined.

B. New and Improved Products and Processing Technology

1. Product Developments. Polyurethane for insulating purposes in structures would be more useful if fire-retardant characteristics were built into the material. Reactive type fire retardants (that is, those containing hydroxy groups) produced foams that are self-extinguishing without lowering compressive strength seriously. Brominated castor oil was evaluated as a fire retardant polyol component. The addition of as little as 2% antimony oxide to the polyurethane system based on brominated castor oil made self-extinguishing foams. Several polyglycerol esters of castor acids were evaluated as rigid foam components. These modified castor acids may be used with a minimum addition of triisopropanolamine crosslinking agent. Foams with a wide range of open cell content were produced using the polyglycerol esters. The open cell content of such foams can thus be adjusted to meet specific industrial requirements (for example, in air filters and sponges). A re-evaluation of the insulating value of polyurethane foams was conducted

on plywood box molds which closely approximate end use conditions. Undisturbed castor-based foams had a low heat transmission which did not increase with age.

An improved mixed anhydride synthesis developed by Departmental scientists has been used to produce over 40 new substituted amides from castor-based hydroxy acids. Selected members of this series are undergoing evaluation as mold release agents and foam stabilizers. This system was also used to prepare a new class of compounds, the symmetrical anhydrides of hydroxy acids, containing mutually reactive functional groups. The anhydride from 12-hydroxystearic acid has been evaluated industrially as an epoxy resin curing agent. Fourteen acrylate esters of castor have been prepared and are being purified and characterized before polymerization studies are undertaken in contract research at the University of Arizona. Work there on the co- and homo-polymerization of vinyl esters of castor derivatives is essentially completed, and evaluation of the polymers is planned. The mechanism of the catalytic isomerization of methyl ricinoleate to methyl 12-ketostearate has been elucidated. Information gained has aided in the design of more economic routes to this potentially valuable industrial compound.

2. Animal Feeds. Castor pomace samples were deallergenized by moderate treatment with ammonia and water and found to be non-allergenic by monkey tests which were confirmed with 200 human patients in Marseilles, France in collaborative work with Dr. Panzani. The mechanical difficulties of scaling up to laboratory deallergenization of pomace with ammonia have been overcome and complete deallergenization as judged by pharmacological criteria was accomplished using sodium hydroxide, potassium hydroxide, calcium hydroxide, ammonium hydroxide, or gaseous ammonia. With gaseous ammonia it was necessary to form a water slurry of the pomace before treatment Other reagents were used in solution so that slurries were formed during the process. In-plant control methods for deallergenization will need simplification. Steam treatments of castor pomace in the absence of the other reagents did not completely remove the allergenicity.

Sufficient castor pomace was deallergenized using ammonia gas in a high water-to-solids ratio to permit a chick bioassay of the feed value. No unusual symptoms attributable to the ammoniation appeared in the birds and the protein appeared to be acceptable for feed. Plant-scale trials of deallergenization by cooperation with a commercial producer of castor oil are planned for the near future. Attempts are being made to find pressures and temperatures more suitable for commercial deallergenization.

Safflower meal supplemented with adequate lysine yields extremely high growth rates in chicks. Feed efficiency is impaired, presumably by residual hull fiber in the partially decorticated meal, and additional studies on low-fiber meal are anticipated.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

Diamond, M. J., Applewhite, T. H., Knowles, R. E., and Goldblatt, L. A. 1964. Preparation of phosphorus esters of long-chain hydroxy fatty acids. J. Amer. Oil Chem. Soc. 41(1), pp. 9-13.

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Layton, Laurence L., Panzani, R., Greene, F. C., Green, T. W., and Smith, Jerry D. 1963. Castor bean allergy as cross-reactive hypersensitivity to the spurges (euphorbiaceae): absence of reaction to chlorogenic acid in primary allergy to castor beans. Internatl. Arch. Allergy & Appl. Immunol. 23(5), pp. 225-238.

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Layton, Laurence L. 1964. Allergy tests upon monkeys passively sensitized with human atopic allergy sera. "Traite de Biologie Appliquee" Tome III, "Les Diagnostics Microbiologiques," H. R. Oliver, ed., Librairie Maloine, Paris, pp. 769-775.

Layton, Laurence L. and Greene, Frank C. 1964. Passive transfer of human allergies to prosimians: skin-reactions in the lemuroid, Nycticebus Coucang (slow loris). Proc. Soc. Expt. Biol. & Med. 115(3), pp. 667-671.

Nelson, Jane S. Goldblatt, L. A., and Applewhite, T. H. 1963. Symmetrical anhydrides of hydroxy acids. J. Org. Chem. 28(7), pp. 1905-1907.

Panzani, Raphael and Layton, Laurence L. 1963. Allergy to the dust of Ricinus Communis (castor bean): clinical studies upon human beings and passively sensitized monkeys. Internatl. Arch. Allergy & Appl. Immunol. 22(6), pp. 350-360.

New and Improved Products and Processing Technology

Lyon, C. K., Garrett, Vilma H., and Goldblatt, L. A. 1964. Rigid urethane foams from blown castor oils. J. Amer. Oil Chem. Soc. 41(1), pp. 23-25.

Shono, Toshiyuki and Marvel, C. S. 1963. Preparation and polymerization of vinyl 12-hydroxystearate. J. Polymer Sci. Part A, 1(6), pp. 2067-2074. (Contract)

REPLACEMENT CROPS - UTILIZATION POTENTIAL
Western Utilization Research and Development Division, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available that would have new end-use patterns. For example, it would be advantageous to develop a new oilseed crop yielding fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species, followed by additional research to explore uses and demonstrate industrial potential, and by additional agronomic research to establish proper cultural practices and select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of pressure for greater national self-sufficiency, the nation will benefit from availability of practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants, and on by-products from processing, such as oilseed meals.

USDA AND COOPERATIVE PROGRAM

Basic and applied research is being conducted on hydroxy-unsaturated acid-containing oilseeds, in the Western Utilization Research and Development Division's headquarters laboratory at Albany, California; and by contract at Fargo, North Dakota. The basic, compositional studies emphasize the development of special analytical techniques for application to new oils containing hydroxy-unsaturated fatty acids. In the applied area, research is conducted to develop and evaluate industrial products from the hydroxy-unsaturated oils.

The Federal program of research in this area totals 4.2 professional man-years, including contract research at a rate equivalent to approximately 0.2 professional man-years per year. Of this total, 2.6 are assigned to chemical composition and physical properties; and 1.6 to industrial utilization.

PROGRAM OF STATE EXPERIMENT STATIONS

Discovery and preservation of valuable plant germ plasm is a continuing objective of the station program in new crops. Much of the research in this area is being done via four regional projects and in cooperation with regional centers. A large portion of the work is cooperative with USDA. Each year many plant introductions are grown and evaluated. Annual and perennial crops possessing potential for industrial or agricultural use are further evaluated for agronomic and chemical qualities. These include crops for paper pulp, drugs, insecticides, polysaccharide gums, and oils rich in acids of unusual structure. Assay of native and introduced tropical plants for products of economic value receives special attention.

Basic aspects of this program involve study of the biochemical and physiological bases for differences in crop plants. Attempts are made to determine if differences in biochemical or physiological processes can be associated with particular factors related to quality. Information concerning carbohydrate transformations is sought through study of carbohydrate formation and enzyme mechanisms.

Horticultural specialty crops are gaining in importance. A number of studies are underway to facilitate rapid development of this industry.

The total scientific effort devoted to replacement crops is 9.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Dimorphotheca and Lesquerella Seed Oils. Oils of Dimorphotheca sinuata and wild members of the mustard family, the Lesquerellas, are being isolated, purified, and analyzed. Analysis by far ultraviolet provides a useful tool for identification of unsaturated fatty acids from these and other oils. Constitutional information and preparative and purification methods were advanced as preliminary steps to finding profitable uses for Lesquerella and Dimorphotheca oils. Methyl esters of separated fatty acids from these oils were synthesized to provide starting materials for new derivatives which will be screened for industrial utilization.

B. Industrial Utilization

1. Industrial Products from Hydroxy-Unsaturated Oils. Large lots of L. densipila, L. gordonii, and L. fendleri oils were processed, converted by

base-catalyzed methanolysis, and purified by fractional distillation at reduced pressure. Methyl lesquerolate was pyrolyzed to methyl 12-tridecenoate which was converted in high yield to 13-amino tridecanoic acid. This amino acid is the building block for nylon-13. Improved techniques were developed for alkaline cleavage of the conjugated hydroxy systems in fatty acids from these seed oils. The hydroxy acids obtained should yield interesting linear polymers. In contract research at North Dakota State University good clear varnishes were developed from isocyanate-modified Dimorphotheca oils. Properties of films made from dehydrated castor and Lesquerella oils were evaluated. Films produced from dehydrated Lesquerella oil and castor oil showed some after-tack, and the Lesquerella oil films were somewhat softer than those of castor oil. Modification in the treatment of these oils and their derivatives is continuing and the relationship of cis-trans isomer content to after-tack is being evaluated. Combinations of hydroxy unsaturated oils under investigation with other diisocyanates will be evaluated for use in surface coatings.

Vinyl esters of 9-chloro and 9-hydroxystearic acid and 14-chloro and 14-hydroxyeicosanoic acid were prepared, purified, and characterized here and their co- and homo-polymerization studied by the contractor. The polymers will be evaluated for industrial value.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

Binder, R. G., Applewhite, T. H., Diamond, M. J., and Goldblatt, L. A. 1964. Chromatographic analysis of seed oils. II. Fatty acid composition of Dimorphotheca oil. J. Amer. Oil Chem. Soc. 41(2), pp. 108-111.

Diamond, M. J., Knowles, R. E., Binder, R. G., and Goldblatt, L. A. 1964. Hydroxy unsaturated oils. II. Preparation and characterization of methyl dimorphecolate and methyl lesquerolate from Dimorphotheca and Lesquerella oils. J. Amer. Oil Chem. Soc. 41(6), pp. 430-433.

REPLACEMENT CROPS - UTILIZATION POTENTIAL
EASTERN REGION
Eastern Utilization Research and Development Division, ARS

Problem. Farmers could achieve economic use of their land if new and profitable crops were available that would have different end-uses than crops presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable.

To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the U.S.; (2) detailed physical and chemical characterization of components and basic research to obtain clues to likely end-uses; (3) selection of the most promising species, followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and select the best strains and varieties.

Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet such long-range research is necessary if agriculture and the nation are to benefit from availability of the best practical crop plants.

To achieve this objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy unsaturated acids, capric acid, epoxy acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants and on byproducts from processing, such as oilseed meals.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists engaged in both basic and applied studies directed to the development of profitable new crops.

At Wyndmoor, Pa., work on new crops totals 5.5 professional man-years. The research is concerned with a study of the oil obtained from the seed of the Indian ironweed (Vernonia anthelmintica), in cooperation with the Northern Utilization Research and Development Division, the Crops Research Division

and the Western Utilization Research and Development Division. The oil contains epoxy fatty acids, potentially useful industrial chemicals.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Discovery and preservation of valuable plant germ plasm is a continuing objective of the station program in new crops. Much of the research in this area is being done via four regional projects and in cooperation with regional centers. A large portion of the work is cooperative with USDA. Each year many plant introductions are grown and evaluated. Annual and perennial crops possessing potential for industrial or agricultural use are further evaluated for agronomic and chemical qualities. These include crops for paper pulp, drugs, insecticides, polysaccharide gums, and oils rich in acids of unusual structure. Assay of native and introduced tropical plants for products of economic value receives special attention.

Basic aspects of this program involve study of the biochemical and physiological basis for differences in crop plants. Attempts are made to determine if differences in biochemical or physiological processes can be associated with particular factors related to quality. Information concerning carbohydrate transformations is sought through study of carbohydrate formation and enzyme mechanisms. Horticultural specialty crops are gaining in importance. A number of studies are underway to facilitate rapid development of this industry.

The total scientific effort devoted to replacement crops is 9.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Progress in the development of Vernonia anthelmintica seed oil as a source of an epoxy-containing oil has been made in the following areas, (1) commercial extraction of 3000 lbs of seed obtained from Pakistan and 750 of domestically grown seed has been carried out through cooperation with an industrial plant under our supervision; (2) over 400 samples of seeds, grown in collaboration with the New Crops Research Branch of ARS have been analyzed; (3) data have been obtained on the efficiency of various solvents used for purifying trivernolin, the chief component of Vernonia oil; (4) domestic seed has been upgraded by an air-flotation procedure that separates the light from the heavy seed; (5) ion-exchange procedures have been employed to remove undesirable fatty acids from Vernonia oil; and (6) separation of unsaponifiable material from the oil by a method previously worked out is being applied to the commercial extracted oil, and the unsaponified material will be evaluated for use in chick feeding. A result of particular interest is that seeds grown above the 39th parallel show low oil yields and the oil is high in free fatty acids and low in epoxy oxygen, indicating immature seeds.

Pronounced commercial interest in Vernonia continues, and industry will be supplied with samples shortly to meet the many requests for Vernonia materials for evaluation purposes. At least one industrial agency has grown

Vernonia on a small scale experimental basis. There is need for more agronomic information, and knowledge of adequate harvesting methods for the seed. Progress in plastic evaluation studies supports the need for commercial evaluation of Vernonia oil and its derived products.

Since processing techniques have been developed and it has been shown that soya extraction plants can be used for Vernonia without extensive modification of equipment, more attention can be given to the preparation and evaluation of modified products and derivatives of Vernonia oil, trivernolin and 12,13-dihydroxy oleic acid. Synthesis of requested vernolic acid derivatives for pharmaceutical studies and further composition studies will be carried out.

PUBLICATIONS AND PATENTS -- USDA AND COOPERATIVE PROGRAMS

Utilization of Oilseeds Containing Epoxidized Oils

Krewson, C. F., and Luddy, F. E. 1964. Vernonia Anthelmintica (L.) Willd. Highly purified epoxy components from seed oil. J. Am. Oil Chem. Soc., 41, pp. 134-136.

Riser, G. R., Hunter, J. J., Ard, J. S., and Witnauer, L. P. 1963. Epoxy acids and salts as stabilizers for vinyl plastics. Soc. Plastics Engrs. J. 19, (8), pp. 1-6.

Sampugna, J., Jensen, R. E., Parry, R. M., Jr., and Krewson, C. F. 1964. Lipolysis of trivernolin by pancreatic lipase. J. Am. Oil Chem. Soc. 41, pp. 132-133.

Scott, W. E., Krewson, C. F., Luddy, F. E., and Riemenschneider, R. W. 1963. Vernonia anthelmintica (L.) Willd. Enzyme studies. Conversion of epoxy-oleic acid to (+) -threo-12,13-dihydroxyoleic acid. J. Am. Oil Chem. Soc., 40, pp. 587-589.

Scott, W. E., Krewson, C. F., and Riemenschneider, Roy, W. June 30, 1964. Preparation of (+)-threo-12,13-dihydroxyoleic acid. U. S. Patent 3,139,387.

Precursors for Steroidal Hormones

Levine, S. G., and Wall, M. E. March 10, 1964. Addition of hypohalites to unsaturated steroids. U. S. Patent 3,124,570.

NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs in nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas total 63.3 man-years. It is estimated that approximately 3.9 man-years is concerned with studies related to oilseeds and peanuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. The basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to lipids are considered briefly in this report.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient Value of Food

Food composition and nutritive value are most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

The form of fats and lipids in food stuffs and the changes involved in processing and holding are receiving special attention as the role of different types of fat in human nutrition unfolds. Protein content and structure continue as active research areas.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in food stuffs as affected by inhibitory and stimulatory factors.

The total program in this area includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

Food preparation research focusing on products for home use include: Heat penetration of meats and baked products and the chemical changes involved; high altitude baking of flour mixes and the effect on final product of type of components as hydrogenated fat or oils; and flavor characterization in frozen and stored products by means of vapor component identification.

This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to other segments of the population or to geographic areas not separately identified in the nationwide studies. Currently 12 States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with preschool children. This research will provide information useful to both consumer and market interests.

The State program in this area totals 22.2 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8 "Composition of Foods...raw, processed, prepared" has been supplemented by further research during the year and adapted to the needs of special projects.

Formulas and procedures that were used in calculating the nutritive values of 250 food items commonly prepared at home are being summarized in a publication for special users, particularly therapeutic dietitians and medical research workers. A table showing average adjustments for vitamin losses during cooking has been developed and will be included in the publication.

Selected data from revised Handbook No. 8 have been made available in decks of punched cards and magnetic tape for research workers. Available in these forms are the data from Table 1, the nutritive values for 100 grams edible portion of the foods; from Table 2, nutritive values for one pound of food as purchased; from Table 3, selected fatty acids in foods. Arrangements have been made for the sale of the cards and the tape by a private data processing firm in Washington.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.

2. Vitamins. Analyses for the vitamin B_6 content and distribution in a variety of foods available to and as eaten by consumers are nearly completed. Manuscripts including data on soybean flour and Virginia peanuts roasted in the shell are in process. Analyses on meats and vegetables are in progress.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B_6. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B_6 in foods.

Development of coordinated procedures for B-vitamin analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

3. Proteins and Amino Acids. Growth response of Leuconostoc mesenteroides P-60 was greater on peanut butter and oatmeal hydrolysates than on simulated amino acid mixtures, but growth was the same on a lactalbumin hydrolysate and a simulated amino acid mixture. The nutrient in oatmeal affecting growth of the organism was identified as vitamin B_6, and that in peanut butter as niacin. A manuscript presenting these findings has been accepted for publication in the Journal of Nutrition. A second manuscript presenting data on the relation between different forms of vitamin B_6 and total nitrogen required for maximum growth of L. mesenteroides is in preparation. Investigations have been continued on the effect of (1) additional factors in food hydrolysates on the growth of L. mesenteroides and (2) the type of carbohydrate in the basal medium on the amino acids required by this and other microorganisms.

B. Properties Related to Quality and Consumer Use of Food

1. Measuring performance of fats in cakes. The effectiveness of physical measurements in indicating differences in consumer eating quality characteristics of white cakes was calculated from data obtained in the study of the performance of five kinds of fats in preparation of cakes in households. Viscosity of cake batters and shear force measurements of cakes were good methods for assessing performance of fats as illustrated by high correlations with panel scores for tenderness, velvetiness, and evenness of grain of cakes. Volume of cake was also a good measure of performance of fats, whereas compressibility of cake was a rather poor one.

2. Use of agricultural chemicals. The flavor of roasted peanuts from peanuts grown on phorate-treated soil was significantly better than that of peanuts from plots without insecticide treatment. This flavor difference was not apparent in peanut butter made from the two lots of peanuts. The peanuts evaluated were the Virginia Jumbo Runner 56R variety grown at Holland, Virginia. The soil treatment was with two pounds active ingredient per acre phorate (O, O-diethyl-S-(ethylthio)methyl phosphorodithioate, a systemic insecticide).

3. Food distribution program. Revision of the publication "Quantity Recipes for Type A School Lunches" (PA-631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of products were updated to take into account recent research findings and technology. New recipes were laboratory tested and taste panel evaluated, and all formulas and serving yields were recalculated in line with the 1964 revision of PA-270, Food Buying Guide for Type A School Lunches.

C. Nutritional Evaluation of Fats and Oils

Heated and oxidized fats. Lifetime studies with rats to determine the effect of heat treatment upon the nutritive value of cottonseed oil, lard, corn oil, and hydrogenated vegetable oil, conducted in contract research at Chicago, Illinois, are nearing completion. These fats, when heated more severely than is usual but still comparable to some food preparation practices, had increased viscosity, decreased iodine value and linoleic acid content, and increased urea-nonadducting fraction as compared to the unheated fats. Rats fed diets containing the heated fats had a slight but consistent retardation in growth during the first year of life, and a tendency toward increased food intake and decreased food utilization. After two years, the rats fed heated fats seem to be aging at about the same rate as rats fed unheated fats. The few rats still living are being sacrificed as they reach 928 days of age.

In other lifetime studies nearing completion, rats were fed diets containing fresh and mildly oxidized olive and cottonseed oils in contract research in New York City. The last of 140 rats fed these oils died of natural causes at 984 days of age. The rats fed cottonseed oil tended to have higher food consumptions, were heavier, and had higher death rates than those fed olive oil. The rats fed oxidized cottonseed oil had a higher death rate than those fed the fresh oil but the reverse was true for the rats fed olive oil. Neither the type nor treatment of dietary fat was related to the cause of death as determined at autopsy although kidney and heart lesions were more severe for rats fed oxidized cottonseed oil. Analyses of serum and tissues of rats sacrificed at different ages showed (1) only slight differences in cholesterol content of serum, liver, brain, and kidney and these did not appear to be correlated with survival rate, (2) considerably less palmitate in heart and kidney triglycerides for rats fed oxidized versus those fed fresh oils but no significant differences in the overall fatty acid composition of these and other organs, and (3) larger amounts of calcium in the livers but not in the hearts, kidneys, and serum of animals fed oxidized oils and no differences in sodium, magnesium, potassium, and phosphorus content of these tissues. Dietary fat did not affect the size of the heart or kidney at any age. In a second lifetime study under contract at the same location, rats have been fed fresh and mildly oxidized lard and butter oil for 36 weeks. The results given here have been presented at scientific meetings or published.

D. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals. A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individuals in the households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C. during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group: (1) the nonresponse rate on food intakes from individuals is not influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families. A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Division, ERS to assist the AMS to administer the food stamp and direct distribution programs.

3. Food consumption of the rural population in Spain (PL 480 Research). A survey of the food consumption of the rural population in Spain has been initiated by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using PL 480 funds. The study will provide information needed in appraising potential markets in Spain for U. S. farm products and should yield information useful to U. S. authorities on efficient ways of improving nutrition in low-income areas. The Spanish Ministry of Commerce expects to obtain much useful information on which to base a program for improving the diets of rural families, especially through better distribution of food. Information on food consumption, income levels, and related socio-economic characteristics has been obtained from about 1,200 rural families in 6 major regions of Spain. In summarizing the results, emphasis is being placed on (1) determining the nutritional shortages among these rural families at different income levels in the different regions, and (2) computing income elasticities for different foods as well as total food consumption.

4. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin, and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched

For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

5. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Food budgets at different cost levels for individuals and families are priced quarterly for publication in Family Economics Review as a continuing service to welfare workers, extension agents, and others needing this information. For example, in June 1964, the cost of one week's food for a family of four including 2 school-aged children, was estimated to be $24.40, $32.80, and $37.40, respectively, for the low-cost, moderate-cost, and liberal plans.

The food budgets published in Home Economics Research Report 20, "Family Food Plans and Food Costs," has been reexamined in the light of revisions in food composition data (Handbook 8, revised) and in recommended dietary allowances of the National Research Council. Some modification in food quantities was needed for certain individuals. This has necessitated revision of food plans and their presentation in technical and popular publications, including Agriculture Handbook 16, "Planning Food for Institutions," now being readied for publication. The "Food Purchasing Guide for Group Feeding," formerly a part of Agriculture Handbook 16, is in the final stages of editing for publication as a separate handbook.

All other existing guidance materials for nutrition programs were reviewed in light of the changes in recommended dietary allowances and in food composition data. Some publications have been revised; others will be updated for the next reprinting.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Labels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

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Properties Related to Quality and Consumer Use

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1964. Food buying guide for type A school lunches. Agricultural Marketing Service; Agricultural Research Service; and Fish and Wildlife Service, U. S. Department of Interior cooperating. PA-270, 75 pp.

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Food Consumption and Diet Appraisal

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OILSEEDS AND PEANUTS - MARKET QUALITY
Market Quality Research Division, ARS

Problem.

Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin and with insects developing resistance to protective pesticidal treatments suggest the desirability of a complete revaluation of handling and storage methods for farmers' stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi, insects, and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration while in the marketplace through improper aeration, drying, handling and storing. Earlier studies conducted on the effect of artifically drying on peanut flavor and quality have not been conclusive. In addition, studies on shelling of farmers' stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., research on peanuts is done at Washington, D. C., Beltsville, Md., Raleigh, N. C., in cooperation with the North Carolina State College and Federal State Inspection Service, at Albany, Ga., in cooperation with the University of Georgia, and also has an agreement with the Agricultural Experiment Station of the University of Georgia at

Experiment, Ga., for making taste panel evaluations of cured peanuts, and by research contract with Texas A & M, College Station, Tex.

A 4-year study of storage changes which is being made at the College of Agriculture, Olsztyn, Poland, will be completed in 1964. This P. L. 480 grant provides an equivalent in Polish zlotys of $18,127.00.

Under a P. L. 480 grant with Universita Di Firenza, Instituto di Industrie Agrarie, Florence, Italy, the second of a five-year study was completed on the effect of containers on long time storage of edible oils and the effect of certain natural and synthetic antioxidants on the oil during storage. This study involves P. L. 480 funds with an equivalent of $26,344.61 in Italian lire.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years. Of this number 5.0 are devoted to quality evaluation and 1.0 to quality maintenance.

The Department also has a continuing program at Tifton and Savannah, Ga., involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination, and of pesticide residues in peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service, the Transportation and Facilities Research Division, the Field Crops and Animal Products Branch, growers' cooperative associations, and various industry groups.

The Federal scientific effort devoted to entomological research on prevention of insect infestation totals 3.0 professional man-years. In addition, much of the cross-commodity research at Savannah, Ga., reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored peanuts.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

A considerable amount of the genetic, breeding, variety and cultural research on oilseeds and peanuts has the ultimate objective of increased market quality. Other studies are generally directed to determining the influence of variety, stage of maturity and harvesting and handling practices on the market quality of the oilseed crop.

In the case of peanuts, the breeding objectives relate to yield, disease and insect resistance, local adaptation and trueness to market types. Studies more directly related to quality are concerned with the effects of

fungi on market value of the seeds and the fermentation products produced by fungi growing on peanut substrates. Market quality studies relate to effects of mechanical harvesting and curing, temperature-time-moisture relationships on keeping quality and on the market value of peanuts as affected by changes in storage. The quality of processed peanut products is being studied and the relationship of maturity and curing practice to finished product quality is being determined.

Research which relates to the history and control of insects affecting peanuts, soybeans and other oilseeds is reported in Area 13. Factors which affect soybean quality are involved in such breeding program objectives as improved resistance to disease, high oil content and seed quality. Illinois is evaluating the quality of soybeans and soybean products for human consumption. Missouri is researching genetic and environmental factors which affect the market value and quality of soybean seed for planting. Other research is directed to solving problems associated with storage and handling of oilseeds. For example, developments in the mechanization of castor bean production and handling are being investigated. Along with developments on production, state stations study the effects of conditioning and storage upon market value.

Total market quality research effort on peanuts and oilseeds at the state stations is approximately 6.7 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. Studies on sampling shelled peanuts from bags have shown that a considerable percentage of the splits found in grading samples are caused by drawing samples from the bags with a seed trier. It was also shown that the seed trier draws the sample from the periphery of the bags and very few if any kernels from the center of the bags. Tests have shown that the percent of splits caused by the trier can be greatly reduced by inserting the trier only three or four inches into the bag and catching a grading sample after discarding the first 100 grams of kernels that flow from the trier.

Studies on the respiration of peanuts during the curing process have demonstrated that there is a correlation between off-flavor in peanuts and anaerobic respiration. The results strongly suggest a relationship, the exact nature of which is as yet undetermined.

A study of the effects of windrow orientation on the quality of peanuts indicates that plants in a windrow can be inverted so that the peanuts are exposed to solar radiation without significantly reducing milling quality or producing off-flavors. Peanuts exposed to the sun, dry more rapidly, and can be harvested more quickly after digging. The study also indicates that the amount of visible damage and field losses caused by inclement weather can be reduced by inverting the plants and harvesting the peanuts with above 20 percent moisture. (MQ 3-29)

2. Evaluation of Damage Factors in Peanuts. Twenty-one volatile compounds were isolated and separated from off-flavor peanuts. Eleven of the twenty-one are formaldehyde, acetaldehyde, ethanol, acetone, isobutyraldehyde, ethyl acetate, butyraldehyde, isovaleraldehyde, 2-Methyl valeraldehyde, methyl butyl ketone and hexaldehyde. Of the remaining ten compounds, one has been identified as either 2-Methyl 1-butanol, or 3-Methyl 1-butanol, one has been tentatively identified as furfural, one has been assigned a ketone functional group and the remaining seven compounds remain completely unidentified. Studies indicate that high temperature off-flavor is due to an enzymatic and/or sporogenic process. It has also been shown that this process is not inactivated by the curing treatment.

Taste panel evaluations and skin slippage tests were made on a series of samples which were cured at temperatures of 125°, 135°, and 145° F. Results show a definite trend toward flavor deterioration as the curing temperatures increased. Also as the harshness of the treatment increased the flavor deteriorated. The skin slippage tests indicated that higher drying temperatures and harsher treatments increased the amount of skin slippage.

Moisture distribution measurements made on the mechanically cured peanuts, indicated that the skin moisture of the peanuts is related to the maturity. Further testing with this technique will be carried out.
(MQ 3-26(c))

B. Quality maintenance in storage

1. Flaxseed Storage. A study under a P. L. 480 grant in Poland on the influence of storage changes on the quality of flaxseed and the quality of linseed oil has been under way three years. Initial tests have been made on flaxseed and linseed oil extracted from the seed and comparisons will be made at 2-month intervals during one-year's storage. (E21-AMS-6)

2. Soybean Oil Storage. All tests originally planned in this project have been completed. Statistical analyses of the data do not indicate significant relationships between the original oils and the quality changes taking place during storage. Loss of antioxidants and increases in secondary oxidation products will now be determined. (MQ 2-44)

3. Natural Antioxidants in Vegetable Oil Storage. About one-third of the samples being held at six constant temperatures (from 70-120° F) are now being tested for possible change in quality. These samples include refined and crude cottonseed, soybean, corn and safflower oils, as well as mixtures.

Preliminary results indicate the efficacy of the gossypol content of the crude cottonseed oils and the tocopherol content of the cottonseed and soybean oils in delaying the oxidation reaction at the different storage temperatures. It appears that such measurements on the original oils, along with determinations of primary and secondary oxidation products, will enable predictions to be made of possible quality changes in the major vegetable oils during commercial storage conditions. (MQ 3-25)

4. Vegetable Oil Storage. During the second year this P. L. 480 grant in Florence, Italy, covered the storage of oils held at 30° C and 40° C for a period of up to 257 days. Little change was noted in quality at 40° C for raw and refined peanut oils. Only minor changes were observed in the crude and refined olive oils. However, there was a significant decrease in quality of refined soybean oil and some decrease in quality of crude soybean oil. At 30° C, there were insignificant changes in all oils except refined soybean oil, where oxidation changes were evident. (E15-AMS-12(k))

C. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory tests were conducted to evaluate potential protectants applied on farmers' stock peanuts. Fenthion gave greater immediate toxicity to the normal laboratory strain of the confused flour beetle than did the standard malathion treatment. Compounds less effective than malathion were diazinon, dichlorovos, naled, and carbaryl. (MQ 1-15)

2. Insecticidal Control. Laboratory dosage-mortality studies with methyl bromide established that 6.2 to 13.3 mg./liter in shelled peanuts and 6.4 to 9.5 mg./liter in farmers' stock peanuts killed 95 percent of red flour beetle adults and larvae and Indian-meal moth larvae exposed 24 hours at 80° F. The moth larvae were most susceptible, followed by red flour bettle adults, and the beetle larvae were most resistant. (Exploratory)

Observations in peanut shelling plants have revealed many sources for insect infestation. Most could be eliminated by a diligent sanitation program combining good housekeeping and the use of residual sprays. It appears that most of the insects infesting farmers' stock peanuts received at the shelling plant are removed by the cleaning steps of the shelling operation. This puts most of the responsibility for providing insect-free shelled peanuts directly upon the shelling plant operator. Observations of

several methyl bromide fumigations of shelled peanuts in trucks and rail cars revealed a number of improper or inadequate procedures responsible for poor results. (Exploratory)

Observations in farmers' stock peanut warehouses showed the almond moth to be the predominant insect. Even though moths were present in a number of warehouses, the malathion surface sprays were holding insect damage to a very low level. Probe samples analyzed for malathion residue contained considerably more malathion than did samples last year. The residue on the shelled nuts was well under the tolerance level. An experiment to determine the loss of malathion resulting from varying degrees of handling treated nuts through commercial conveying equipment did not reveal any significant loss from such handling. The greatest and most rapid depletion of malathion deposit occurred during the first two or three months of storage. (Exploratory)

Moths and beetles collected from warehouses where malathion had been used for one to five years were tested for resistance. A twenty-fold resistance to malathion was found in one strain of flour beetles, five-fold in a strain of the almond moth, and eight-fold in a strain of Indian-meal moth. The most resistant strains were all from peanut silos where malathion was being used for the third year. (MQ 1-23)

3. Nonchemical Control. Peanuts stored in high concentrations of CO_2 or N_2 and in normal atmosphere retained relatively constant germination during the first 6 months but lost about 30 percent during the next 3 months. There was further loss by the end of one year but the nuts in CO_2 or N_2 retained a higher rate of germination than did those stored in normal air. Quality tests by the Georgia Agricultural Experiment Stations showed a generally better condition for the nuts stored one year in CO_2 or N_2 than for those in air. (Exploratory)

Flow-rate studies in small stainless steel towers containing farmers' stock peanuts showed that N_2 gave more uniform purging of O_2 and a slower rate of O_2 diffusion back into the towers than did CO_2. Observations on insects showed that 80 to 100 percent mortality occurs within 7 days if (1) CO_2 concentration is 70 percent or more, (2) N_2 purging reduces the O_2 content to about 2 percent, or (3) CO_2 purging reduces O_2 to 13 percent and increases CO_2 to 50 percent. Preliminary observations on the changes in atmospheric gas concentrations in sealed containers of infested and noninfested shelled and farmers' stock peanuts indicate that (1) O_2 reaches the lowest level after 3 to 6 weeks, and (2) concentrations of N_2 are higher and CO_2 are lower in shelled than in farmers' stock peanuts. (Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Beasley, E. O. and J. W. Dickens. 1963. Engineering research in peanut curing. N. C. Agr. Expt. Sta. Agricultural Engineering Technical Bulletin No. 155.

Whitten, M. E. and L. A. Baumann. 1963. Evaluation of a rapid method for determining oil content of soybeans. USDA Technical Bulletin 1296.

Prevention of Insect Infestation

Harein, P. K. 1963. Marketing: Research on insect control. Peanut Research 1(2):7.

Redlinger, L. M. 1963. Insect control in stored peanuts. Proceedings, Second National Peanut Research Conference, North Carolina State College, Raleigh, N. C., August 13-15, 1962.

MARKETING FACILITIES EQUIPMENT AND METHODS
Transportation and Facilities Research Div., ARS

Problem. Differences in varieties of oilseeds and peanuts and in the environments of producting areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to efficient and economical handling, conditioning, and storing these crops and to maintaining their quality. There is a need for improved designs of facilities based on functional and structural requirements, which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program involving both applied and basic research as well as application of known principles to the solution of problems of handling, storing, and conditioning field crops in marketing channels. Research on the handling, drying, aerating, and shelling of peanuts is conducted by the Albany, Georgia, field office at laboratory and pilot-scale facilities in Dawson and Bainbridge, Georgia, in cooperation with the Georgia Agricultural Experiment Stations, and with various industry firms. The Federal effort devoted to research in this area totals 4.0 professional man-years to handling, drying, aerating, storing, and shelling of peanuts.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

Shelling, Handlirg, Drying, Aerating, and Storing Peanuts

1. Shelling. About 160 tons of Spanish-, Runner-, and Virginia-type peanuts were shelled in the experimental shelling plant at Dawson, Ga., during the 1963-64 shelling season. Peanuts were obtained for the tests from the Southwest, Southeast, and Virginia-Carolina producing areas.

Sheller speeds between 215 to 245 RPM were superior for shelling Virginia-type peanuts with Medley shellers when shellers were operated over a total range of 175 to 325 RPM. These results substantiated those of shelling tests on Virginia-type peanuts from the 1962-63 season. Spanish-type peanuts were shelled using both a Medley sheller and a basket-type grate. The Medley sheller caused the least mechanical damage when operated at 225 RPM; the basket-type grate when operated at 185 RPM. The two types of

shellers appeared to be about equal in rate of shelling. Only the Medley sheller was used to shell Runner-type peanuts and shelling speeds from 215 to 235 RPM caused the least mechanical damage.

Results of research during two seasons indicate that the speed of Medley shellers should not exceed 225 RPM for Spanish-, 235 RPM for Runner-, and 245 RPM for Virginia-type peanuts. Limited tests also indicate that the Medley (grate-type) sheller and the basket-type sheller are about equal in shelling performance when each is operated at its optimum speed which generally will be different for each sheller.

Motion pictures of the shelling action of conventional shellers indicated that shelling is caused by pressure applied to the shells rather than by stirring action; also, that only about three-fourths of the grate surface in a Medley sheller is in use during shelling.

Cleaning.--Some progress was made toward improving the performance of the Simon-Carter scalperator for cleaning farmers stock peanuts. This equipment, while removing an acceptable proportion of the foreign material, also removed a relatively high percentage of peanuts. Cleaning equipment was developed that substantially reduces the number of peanuts removed with the foreign material, but further adjustments and refinements are needed for removing a larger percentage of foreign material. The results and ideas gained from the tests need further application to actual cleaning operations.

Presizing.--Sizing tests were run to determine the number of size-groupings of farmers stock peanuts required for optimum shelling operations. Results indicate that it is possible to separate the general run of Spanish- and Runner-type peanuts into about 4 size-groupings for shelling. Tests were run on only one variety of Virginia peanuts, NC-2, and additional data are needed on other varieties of this type.

2. Handling. Results of continuing tests with the pneumatic conveyor at Bainbridge, Ga., showed that mechanical damage totaled 8 percent for Spanish-, 33 percent for Virginia-, and 10 percent for Runner-type when peanuts were elevated about 30 feet and dropped into a bin. Limited tests on moving peanuts horizontally with the pneumatic conveyor indicated this method to be more costly than the common method of shoveling peanuts onto a belt conveyor. Feeding peanuts into the pneumatic system from a stored pile was both time consuming and laborious and resulted in a lower handling rate than the system using a belt conveyor.

Tests with conventional bucket elevators indicated that a 12-inch spacing of buckets was superior to a 6-inch spacing for elevating farmers stock peanuts. Although mechanical damage was not significant with either spacing, the 12-inch spacing gave a higher elevating rate.

3. Drying. A total of 81 drying tests with Spanish-, Runner-, and Virginia-type peanuts were run in the experimental pilot-scale drying unit at Bainbridge, Ga., during the 1963 drying season. Two new drying treatments were studied consisting of alternate heating and cooling during the drying process, one with the airflow direction alternated every 2 hours, the other, every hour. These two treatments were compared with a third treatment using continuous heated air moved alternately upward through the bed of peanuts for one hour and then downward for one hour. Heated air temperatures of 125°, 135°, and 145°F. were used with each drying method.

The two new drying treatments were superior to the continuous heat treatment from the standpoint of the amount of mechanical damage to the peanuts that occurred during the shelling process. Each of the two treatments required about one-third as much fuel as the continuous heat method but about one-third more time in the dryer.

Samples of peanuts from each drying test were analyzed to determine the effects of each treatment on peanut taste, splitting, and skin slippage. The number of split kernels were not significantly different in samples from peanuts dried with alternate heating and cooling with the drying air at 135° and 145°F. than in samples from peanuts dried with continuous heating with drying air at 125°F. Results indicate that other quality factors react similarly to various drying treatments. Results to date are not conclusive and drying studies are being continued to determine optimum time-temperature relationships for drying peanuts to obtain the prompt reduction of moisture to minimize mold infection--considered vital in preventing aflatoxin contamination--while maintaining desirable qualities of taste, appearance, etc., of the dried peanuts.

4. Aeration. Tests with stored farmers stock peanuts were continued at Bainbridge, Columbus, and Dawson, Ga.

A total of 865 tons of Spanish-type peanuts stored in an aerated silo at Columbus lost less than 1 percent moisture during the 7-months storage period. The aerated peanuts had a considerably lighter colored skin than peanuts stored with no aeration. Apparently consumers of salted nuts prefer peanuts having the lighter colored skins, so these research results are of particular interest to processors. As a result of this research, the storage firm at Columbus has installed additional aeration equipment.

At Bainbridge, peanuts increased 1.3 percent in moisture during 4 months of aerated storage. At Dawson, Ga., peanuts also increased about 1 percent in moisture during 3 months of aerated storage. These peanuts appeared to shell better at the higher moisture content with somewhat fewer split kernels. An additional benefit was the added weight, which, at the prevailing market price, amounted to an increase of some $2.50 per ton of peanuts stored.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

None.

ECONOMICS OF MARKETING
Marketing Economics Research Div., ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducting costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products.

Market research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Marketing Research also is being directed to the economics of transportation and storage activities of both private firms and Government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective inter-regional shifts in the areas of production and marketing for specific products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program in research to bridge the gap between laboratory developments and commercial adoption so as to fully assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and expanded markets that new products and new uses can afford. Research is carried on in industrial and food uses at Washington, D. C., and field offices. The Federal scientific effort engaged in research on market potential for new products and uses of oilseeds and peanuts is 2.1 professional man-years.

Research in the area of marketing margins, costs, and efficiency is designed primarily to provide useful information on the amounts and trends in marketing margins, costs of marketing, labor and equipment requirements, cost standards, economies of scale, and other factors including marketing channels and types of firms and for all farm products marketed in commercial volumes. In nearly all studies close cooperation is maintained with industry and trade groups and with individual private firms that generously provide essential data from their records and make their plant facilities

available for observation and the conduct of various market tests. Although most of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located at field stations in several states. The Federal scientific effort devoted to research in this area on oilseeds and peanuts is 2.4 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Little, if any, research in economics is carried out in these areas by State agricultural experiment station personnel.

PROGRESS--USDA AND COOPERATIVE PROGRAM

A. Market Potential for New Products and New Uses

1. Economics of Whole Soybeans for Feed. Continuing evaluations of the economics of using whole soybeans for feed indicate that soybeans converted by heat treatment at local facilities in soybean-producing areas may be the way to obtain cooked full-fat soybeans for livestock feeds at low cost. Many soybean-growing areas also are important livestock and poultry feeding areas. Soybean oil normally sells at a higher price than feed-grade tallow, because it is an edible fat and feed-grade tallow is not. Price differences of 4 cents a pound or greater between soybean oil and feed-grade tallow can be offset by the nutritional, transportation, handling and processing cost savings offered when soybeans are used this new way. During the 1962-63 crop year, the average price spread between these fats was 3.4 cents per pound. The advantages favoring making a ton of cooked soybeans in various locations in 1962-63 over an equivalent feed made up of 44 percent soybean meal, plus prime tallow were as follows: Arkansas, $8.46; Delmarva, $20.46; Georgia, $15.69; and Ohio, $21.24. The cost advantages in these localities will be even greater for the 1963-64 crop year.

2. Farm Products in Polyurethanes. Studies of the use of farm products in polyurethanes indicate that starch and sugar derivatives are used in largest quantities in current market applications. Fats and oils derivatives are not being used currently in the quantities that earlier trends promised. Laboratory research has been directed to developing improved castor-based foams at lower costs. This research could have an impact on future market applications, but further study will be required to ascertain adequately what the impact may be.

3. Markets for Safflower Products. Research has been initiated and is in preliminary phases on safflower oil to ascertain the share of the edible oils market that it is likely to gain and maintain, competitive relations with other materials, its industrial use possibilities, and the potentials for safflower meal for livestock feeding in the west. This research should be helpful in appraising where this crop will eventually fit in the over-all oilseed production and use pattern.

4. Potentials for Modified Edible Oils. Work was completed on four present and potential edible fats and oils markets to identify applications in which research and development can most effectively contribute to increased use. Product improvements could increase use of domestic modified edible fats and oils by 82 million pounds above normal growth over the next 5 years. Improvements in melting characteristics, gloss, and mold release could bring a 40-million pound growth in confectionery coatings. Improvements in abrasion resistance and transparency and cost reductions could lead to a 35-million pound gain in protective edible coatings. Edible food lubricants usage could be upped by 7 million pounds if tendencies toward rancidity and polymerization were reduced. Little gain can be expected in use of food emulsifiers.

B. Marketing Costs, Margins and Efficiency

1. By establishing the prices which shellers must pay for the various kernel grades of farmers' stock peanuts, the peanut price support program can influence sheller decisions as to the quality of farmers' stock peanuts to market through commercial trade channels. A linear programming analysis of Virginia type peanut sheller responses to the pricing system shows that the most profitable qualities of farmers' stock peanuts for shellers, under current support programs, are those containing high percentages of fancy and low quality peanuts. This finding bears out a common complaint of shellers that too few peanuts of fancy quality are produced. Also, the support price differential between sound, mature kernels and other kernels appears to be too large to induce shellers to move the maximum possible quantity of high quality shelled peanuts through commercial channels. Expanding the programming analysis to include supply restraint for farmers' stock peanuts and demand restraints for shelled peanuts will provide estimates of the total quantities and qualities of farmers' stock peanuts that should move through commercial channels under various assumed conditions.

2. Marketing Margins for Fats and Oils in Selected Consumer Products. The major shift in the utilization of various types of fats and oils in recent years created considerable marketing problems for agencies assembling, processing, and distributing those products. Basic information pertaining to the total production, value and per capita consumption of salad dressing; the production by type of salad dressings and size of consumer containers used; and the consumption of oils, by type, used in the production of salad dressing are being developed. Price spreads on salad dressing are now in the process of preparation. Retail prices are now being analyzed.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

A. Market Potentials for New Products and Uses.

Hester, O. C. and Boggs, R. L., May 1964. Market potential for modified edible fats and oils. MRR-659. pp. 30.

B. Margins, Costs, and Efficiency

Farnworth, Virginia M., December 1963. Prices, marketing margins, and uses of peanuts in peanut butter. MRR-624. pp.25.

COOPERATIVE MARKETING
Marketing Division, FCS

Problem: Farmers are expanding their use of cooperative marketing. There are constant changes in transportation, processing, and distribution technology, and in market organization and practices, and changes on the farm itself. In view of these developments, farmer cooperatives and other marketing firms require research results to perform both efficiently and effectively. Such research can assist farmers to maintain and strengthen their bargaining power, increase efficiency, and meet the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a major way for farmers to get maximum returns from their products in the current and rapidly changing market. Farmers own and control cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan, develop, and actually manage the specific marketing program and services that will yield the most for their members. Marketing cooperatives must know what the market demands. They must be able to compute the probable cost of different ways of serving the market. They must understand the possibility of major economies in a well coordinated joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through improved organization, good use of existing plant and personnel, and the selection and use of new equipment and methods.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 23.3. Of this number, 1.3 was devoted to cooperative marketing of oilseeds and peanuts.

STATE EXPERIMENT STATIONS PROGRAM

The State stations maintain a very broad research program in commodity marketing, the findings of which are valuable to cooperatives and to other marketing firms. There are at this time nine projects in eight States that

deal specifically with cooperative marketing. These projects seek to find out how cooperatives are adjusting or might better adjust to changes in market structure and marketing practices. In some instances, researchers are studying the success and failure of cooperatives and the organizational structure. One study of the history of major cooperative marketing associations in the State will be published as a book and will undoubtedly receive nationwide attention.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Improving operating methods in processing and storage

1. Oilseeds and peanuts. Analysis of operating costs of cooperative soybean processors continued. Data developed in this study assist processors to increase returns to growers through reduced operating costs. Findings also assist in appraising the feasibility of constructing new soybean processing plants.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Biggs, G. W. 1964. Not a 'Peanut' in the Bag. News for Farmer Cooperatives (June-July)

Biggs, G. W. 1964. Marketing Farmers' Stock Peanuts in the Virginia-North Carolina Area. Proceedings of the Third National Peanut Research Conference, Auburn University, Auburn, Alabama.

Jones, E. and King, R. W. 1963. Economic Efficiency in Constructing and Operating Bulk Peanut Receiving Stations. North Carolina State. A.E. 107.

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

USDA AND COOPERATIVE PROGRAM

Fats and Oils. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals developments of interest to the industry, and results of special studies are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation and the National Food Situation and occasionally in monthly issues of the Farm Index and the Agricultural Situation. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference, and more limited appraisals are given at meetings with industry groups. Special analyses are prepared on the probable effect of proposed programs on the acreage, price, supply, and demand for oilseed crops and for fats and oils and their products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Oils, and Their Products, 1909-63, is being revised and updated for publication in the fall of 1965.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

Fats and Oils

In addition to the regular analytic and outlook work, greater attention was given to some of the minor oilseed crops and to expanding foreign markets. Long-run projections were developed for the major oilseeds, fats and oils as part of an overall set of ERS projections for the farm economy.

Special articles were prepared, for the situation reports, on trends and developments in the coconut oil, marine oil, tall oil, and salad dressing products industries as these commodities are not regularly covered in the situation reports. Tall oil production is closely related to the production of pine sulphate pulp, since it is a byproduct of the Kraft paper manufacturing process. Output increased sharply from 125 million pounds in 1943 to a record 990 million in 1963--and may exceed a billion pounds this year. Major factors in the growth of tall oil consumption have been improvement in quality, development of new uses, and its relatively low, steady price compared with the wide price fluctuations of higher-priced linseed and soybean oils. As the demand for paper increases, the sulphate industry will continue to expand, making possible increased production of tall oil. Also improvement in the recovery rate may boost production, as 15 to 20 percent of the soap is not now recovered.

A special article on coconut oil--an import commodity--showed that U.S. imports of coconut oil and copra (mainly from the Philippines) rose steadily from a postwar low of 554 million pounds in 1952 to 720 million in 1963. The proportion imported as oil increased, and comprised 52 percent of the total in 1963. A large part of the increase in imports has been used in food products, which now comprise one-third of total consumption compared with one-fifth prior to 1952. Suspension of the 3-cent processing tax, relatively low steady prices, and liquidation of the national stockpile of coconut oil by the General Services Administration have stimulated domestic use in recent years.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Fats and Oils

Kromer, George W., Fats and Oils Situation. Published 5 times a years. ERS, USDA, Washington, D. C.

Gazelle, Stanley A., May 1964. Recent trends in U.S. production, use, and price of marine oils. Fats and Oils Situation, pp. 29-37.

Kromer, George W., January 1964. Tall oil production to reach billion pound mark in 1964. Fats and Oils Situation, pp. 31-37.

Kromer, George W., March 1964. Coconut oil imports and consumption increasing in the United States. Fats and Oils Situation, pp. 31-40

Kromer, George W., August 1964. Salad dressing products: Demand expands steadily in postwar era. Fats and Oils Situation, pp. 37-42.